

**Species Status Assessment Report**  
for the  
**Sierra Nevada Distinct Population Segment**  
of the  
**Sierra Nevada Red Fox**



Photo by automatic camera, provided by Sarah Stock, NPS

February 2018  
US Fish and Wildlife Service  
Region 8  
Sacramento, CA



## Executive Summary

The Sierra Nevada distinct population segment (Sierra SNRF) of the Sierra Nevada red fox (*Vulpes vulpes nicator*, SNRF) once ranged throughout the Sierra Nevada mountains (Sierras) at high elevations, but is now restricted to a single known population in the vicinity of Sonora Pass, CA. This report examines the current and potential future viability of the Sierra SNRF in terms of three components: resiliency (the ability of a species or distinct population segment (DPS) to withstand stochasticity), redundancy (the ability of a species or DPS to withstand catastrophic events), and representation (the ability of a species or DPS to adapt over time to long-term changes in the environment).

Five environmental characteristics are most likely to have the greatest effect on Sierra SNRF population resiliency. These are: cold subalpine habitat with low primary productivity, high snowpacks, rodent prey, leporid (rabbit and hare) prey, and whitebark pinenut (*Pinus albicaulus*) food caches. Sierra SNRF resiliency is also likely affected by a single demographic characteristic: population size. Although the minimum viable population size for Sierra SNRF is unknown, a study of island foxes (*Urocyon littoralis*) concluded that populations of that species should have at least 150 reproductive adults to avoid inbreeding depression and recover from deleterious chance events. Island foxes are in a different genus from SNRF, and occupy different habitat, but have a similar mating system, and (like SNRF) have been isolated for many years. Accordingly, given the lack of minimum viable population estimates for SNRF itself, we consider 150 adults to be a reasonable, best-available approximation.

To establish levels of redundancy and representation necessary for long-term viability, the Sierra SNRF needs additional demographic characteristics as well. A single large population or multiple smaller populations would provide redundancy by helping to insure that large portions of the DPS remain even after a catastrophic losses over a large area. To ensure representation, the single large or multiple smaller populations should be situated to include habitat variations occurring from northern to southern portions of the range, rather than clustering in one general area. Finally, representation of the species genetic diversity requires that the population(s) avoid the swamping and loss of their adaptive native genes, which could result from continuing and overbroad levels of interbreeding with nonnative red fox subspecies.

The current condition of the five environmental characteristics important for resiliency is generally good or somewhat reduced from historical levels. However, the current condition of the demographic characteristics discussed above is poor. The Sierra SNRF is currently comprised of one known population estimated at about 10 to 50 adults in the center of the DPS's historical range. Recently, at least two nonnative male red foxes have entered the population and produced several hybrid young. Fully native young have not been documented in the past 5 years.

In the future (approximately 50 years) some of the five environmental characteristics important for resiliency are likely to maintain status quo, while others are likely to decline. Significant habitat-based stressors on the future condition of the Sierra SNRF include climate effects on snowpack and subalpine habitat (resulting in increased coyote competition), and decreases in whitebark pinenut availability due to disease and beetle attacks. Significant stressors on

demographic characteristics important to SNRF viability include inbreeding depression and continued hybridization with nonnative red foxes. Conservation actions can potentially ameliorate some impacts from inbreeding depression and hybridization, but plans outlining these types of beneficial actions are in early stages of development, and the likelihood of implementation and success is currently unknown.

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## 1.0 Introduction

The Sierra Nevada red fox is a subspecies of red fox living at high elevations in the Sierra Nevada mountains of California (the Sierras) and the Cascades mountains of California and Oregon (the Cascades). In California, it is listed as endangered under the state Endangered Species Act (CESA, 14 C.C.R. 670.5) (CDFW 2017, p. 12).

In 2011, we (the U.S. Fish and Wildlife Service (FWS)) received a petition (CBD 2011, entire) to list the SNRF as endangered or threatened under the Federal Endangered Species Act (ESA, 16 U.S.C. 1531 *et seq.*). In 2015, we determined that listing the entire subspecies was not warranted (80 FR 60990). We also found that two distinct population segments (DPSs) of the subspecies exist – one in the Southern Cascades (south of Washington) and the other in the Sierras. The ESA defines “species” to include subspecies and DPSs, thereby potentially allowing a DPS to be listed as an endangered or threatened species (16 U.S.C. 1532(16)). To qualify as a DPS, a population must be “discrete” and “significant” in relation to the rest of the species (61 FR 4722, 4725). To be listed as an endangered or threatened species, a DPS must be in danger of extinction throughout all or a significant portion of its range (endangered) or likely to become so in the foreseeable future (threatened). On October 8, 2015, we determined that listing the Southern Cascades DPS (Cascades SNRF) was not warranted, but that listing the Sierra Nevada DPS (Sierra SNRF) was warranted. Further listing procedures for the Sierra SNRF were precluded at that time by higher-priority listing actions with statutory, court-ordered, or court approved deadlines.

We now return to the issue of whether the Sierra SNRF is threatened or endangered, and have produced this Species Status Assessment (SSA) report to help address that question. The report uses the best available science to provide a scientifically supportable analysis of the Sierra SNRF’s viability (its risk of extinction) currently and in the future. We reviewed the biology and natural history of the Sierra SNRF, and assessed demographic risks, stressors, and limiting factors for the analysis. If we list the Sierra SNRF as an endangered or threatened species, we will update the SSA report as necessary to support other functions of our Endangered Species Program, such as for biological opinions, 5-year reviews, and recovery planning. The SSA report does not constitute our listing determination, which we will make subsequently after reviewing this scientific document and all relevant laws, regulations, and policies.

In this report, we consider the viability of the Sierra SNRF both at the present time and in the future, which we define in this case as 50 years because it is within the range of the available hydrological and climate change model forecast (see IPCC 2014). Additionally, 50 years encompasses roughly 25 generations of SNRF (Perrine *et al.* 2010, p. 15), which is a relatively long time in which to observe effects to the species. In estimating the potential viability of the DPS in 50 years, however, we consider information regarding population or environmental trends that may be ongoing at that time. Estimation of trends within 50 years may in turn involve consideration of environmental information from slightly beyond the 50-year time period.

We characterize the current and future viability of the Sierra SNRF based on the resiliency, redundancy, and representation of its population(s) (the three Rs) (Wolf *et al.* 2015, entire).

- **Resiliency** describes the ability of a species to withstand stochastic disturbance. Resiliency is positively related to population size and growth rate and may be influenced by connectivity among populations. Generally speaking, populations need abundant individuals within habitat patches of adequate area and quality to maintain survival and reproduction in spite of disturbance.
- **Redundancy** describes the ability of a species to withstand catastrophic events; in other words, theoretically spreading risk among multiple populations to minimize the potential loss of the species from catastrophic events. Generally, redundancy is characterized by having multiple, resilient populations distributed within the species' ecological settings and across the species' range. Depending on the species or situation, however, a species could also withstand catastrophic events if it is a single population spread out across a landscape. Redundancy can be measured by population number, range-wide resiliency, spatial extent, and degree of connectivity. Our analysis explores the influence of the number, distribution, and connectivity of populations on the species' ability to withstand catastrophic events (e.g., rescue effect).
- **Representation** describes the ability of a species to adapt to changing environmental conditions over time. It is characterized by the breadth of genetic and environmental diversity within and among populations. Measures may include the number of varied niches occupied, the gene diversity, heterozygosity or alleles per locus. Our analysis explores the relationship between the species life history and the influence of genetic and ecological diversity and the species ability to adapt to changing environmental conditions over time. The analysis identifies areas representing important geographic, genetic, or life history variation (i.e., the species' ecological settings).

## 1.1 Approach and Methods

After providing basic background information on the “species” (which in this case is a DPS), we discuss the environmental and demographic characteristics under which the DPS would likely have high viability in terms of resiliency, redundancy, and representation. We then consider the extent to which those characteristics apply, both currently and in the future. For our analysis of future condition(s), we examine scenarios involving both optimistic and pessimistic assumptions regarding likely trends and identify which of those trends is more likely for each characteristic.

We do not closely consider all environmental and demographic characteristics that may contribute to the DPS's viability, but only those for which some current or future stressor could result in a significant negative effect to the DPS's viability, now or in the future. We identify stressors, as well as existing regulatory mechanisms and voluntary conservation actions that might reduce adverse effects or ameliorate those stressors. We then summarize the overall current and future viability of the DPS.

## 1.2 Federal Actions

On April 27, 2011, we received a petition dated April 27, 2011, from the Center for Biological Diversity, requesting that Sierra Nevada red fox be listed as an endangered or threatened species, and that critical habitat be designated under the Act. The petition also requested that we evaluate populations in the Cascades and Sierras as potential DPSs.

In a May 24, 2011, letter to the petitioner, we responded that we reviewed the information presented in the petition and determined that issuing an emergency regulation temporarily listing the species under section 4(b)(7) of the Act was not warranted. We also stated that we were required to complete a significant number of listing and critical habitat actions in Fiscal Year 2011 pursuant to court orders, judicially approved settlement agreements, and other statutory deadlines, but that we had secured funding for Fiscal Year 2011 to allow publication of a finding in the *Federal Register* in early Fiscal Year 2012.

On January 3, 2012, we published a positive 90-day finding (77 FR 45) that the petition presented substantial information indicating that listing may be warranted.

On October 8, 2015, we issued a 12-month finding (80 FR 60990), in which we concluded the following: (1) listing the SNRF as a subspecies was not warranted; (2) the Cascades and Sierra Nevada populations qualify as DPSs; (3) listing the Cascades DPS was not warranted; and (4) listing the Sierra DPS is warranted, but temporarily precluded by higher-priority listing actions.

## **2.0 DPS Background**

### **2.1 SNRF Description**

Red foxes (*Vulpes vulpes*) are small, slender, doglike carnivores (3.5 to 7 kilograms (kg), 8 to 15 pounds (lb)), with elongated snouts, pointed ears, and large bushy tails (Aubry 1997, p. 55; Perrine 2005, p. 1; Perrine *et al.* 2010, p. 5). Diagnostic features, by which red foxes can be distinguished from other small canines, include black markings on the backs of their ears, black shins, and white tips on their tails (Statham *et al.* 2012, p. 123). The fur of most red foxes is primarily yellowish to reddish brown (Perrine *et al.* 2010, p. 5). This is the “red” color fur pattern (sometimes called a “red phase”). At least two additional color fur patterns exist: the “cross” fur pattern and the “black” fur pattern (Aubry 1997, p. 55; Perrine *et al.* 2010, p. 5). The cross fur pattern is primarily grayish-brown, with darker lines along the back and shoulders, crossing behind the neck. The black fur pattern (also called the silver fur pattern) is primarily black, with occasional silver guard hairs. Coat color is genetically determined, but all three color fur patterns may occur in the same litter (Aubry 1983, p. 107; Perrine *et al.* 2010, p. 5). Cross and black fur patterns tend to be rare in red foxes generally, but are more common among red foxes living in cold mountainous areas (Aubry 1997, p. 55; Perrine *et al.* 2010, p. 5).

SNRF average about 4.2 kg (9.3 lb) for males and 3.3 kg (7.3 lb) for females, as compared to the general North American average of about 5 kg (11 lb) for males and 4.3 kg (9.5 lb) for females (Perrine *et al.* 2010, p. 5). This runs contrary to Bergmann’s Rule, a generalization that warm-blooded animals in colder regions tend to be larger than closely related animals from warmer climates, in order to more easily conserve heat (Ashton *et al.* 2000, pp. 390, 407).

The SNRF and two other montane subspecies (see **2.2 Taxonomy**, below) are characterized by what appear to be specialized adaptations to cold areas (Sacks *et al.* 2010, p. 1524). These apparent adaptations include a particularly thick and deep winter coat (Grinnell *et al.* 1937, p. 377), longer hind feet (Fuhrmann 1998, p. 24), and small toe pads (4 millimeters (mm) (0.2 inch (in)) across or less) that are completely covered in winter by dense fur to facilitate movement over snow (Grinnell *et al.* 1937, pp. 378, 393; Fuhrmann 1998, p. 24; Sacks 2014, p. 30). The SNRF's smaller size may also be an adaptation to facilitate movement over snow by lowering weight supported by each footpad (Quinn and Sacks 2014, p. 17), or it may simply result from the reduced abundance of prey at higher elevations (Perrine *et al.* 2010, p. 5).

## 2.2 Taxonomy

The SNRF was first identified (as a full species, *Vulpes necator*) in 1900 by Clinton Merriam, who recognized a total of 10 North American red fox species, and 2 subspecies (Merriam 1900, pp. 662, 664). In 1936, all North American red fox species and subspecies were redesignated as subspecies of *Vulpes fulva* (Bailey 1936, pp. 272, 317). The SNRF thus became the subspecies *Vulpes fulva necator*. In his Ph.D. thesis, Charles Churcher (1957, p. 200) redesignated all North American red foxes as subspecies of *Vulpes vulpes*, due to the lack of any clear demarcation between *Vulpes vulpes* foxes in Siberia and *Vulpes fulva* foxes in Alaska. The SNRF thus became *Vulpes vulpes necator*. Churcher (1957, p. 202) also eliminated 3 of the 12 previously recognized North American subspecies: *Vulpes fulva bangsi*, *V. f. deletrix*, and *V. f. kenaiensis*. Churcher (1957, pp. 193, 195, 202) questioned the distinction of the SNRF from the Cascade red fox (*V. v. cascadiensis*), but concluded he lacked sufficient samples to make a determination. Much of this work, including redesignation of *V. fulva* to *V. vulpes*, was published 2 years later in the *Journal of Mammalogy* (Churcher 1959, p. 519), but the article did not mention elimination of the three North American subspecies.

Aubry (1997, p. 55) considered the SNRF to be 1 of 9 subspecies of red fox in North America, based on the 12 forms identified by Merriam (1900, pp. 662, 664) minus the 3 eliminated by Churcher (1957, p. 202). However, Hall (1981, p. 938) continued to recognize *Vulpes vulpes kenaiensis*, leaving the SNRF as 1 of 10 North American subspecies. A recent conservation assessment of the SNRF, conducted for the U.S. Forest Service, adopted Hall's position (Perrine *et al.* 2010, p. 5). The Integrated Taxonomic Information System (ITIS), a database of taxonomic information maintained by a partnership of U.S. Federal agencies, continues to recognize all 3 of the forms purportedly eliminated by Churcher (ITIS 2014, p. 1), thus making the SNRF 1 of 12 North American subspecies. A 1996 summary of red fox taxonomy by the American Society of Mammalogists also recognizes the three subspecies purportedly eliminated by Churcher (Lariviere and Pasitschniak-Arts 1996, pp. 1, 2). Finally, none of these various counts of North American subspecies reflects the recent (2010) designation of the Sacramento Valley red fox (*Vulpes vulpes patwin*) (Sacks *et al.* 2010, pp. 1,523, 1,535). The SNRF can thus reasonably be considered 1 of 10, 11, or 13 North American subspecies of *Vulpes vulpes*, depending on sources referenced.

The SNRF is one of three closely related and ecologically similar western montane subspecies (Aubry 1983, p. 1; Aubry 1997, p. 55; Perrine *et al.* 2010, p. 5). The other two are the Rocky

Mountain red fox (*Vulpes vulpes macroura*) and the Cascade red fox (*Vulpes vulpes cascadenensis*) (Statham *et al.* 2012, p. 122). The Rocky Mountain red fox occurs in the Rockies and other mountainous areas of Idaho, Montana, Wyoming, Utah, Colorado, New Mexico, Nevada, and Eastern Oregon (Sacks *et al.* 2010, pp. 1,528, 1,536). The Cascade red fox occurs in the Washington Cascades north of the Columbia River (*Id.*). Note that the Cascade red fox is different from what we term the Cascades SNRF, which is a population of *Vulpes vulpes necator* living in the Cascades south of the Columbia River. The range of the Cascade red fox was previously thought to also include the Oregon Cascades, but recent genetic comparisons have shown red foxes of the Oregon Cascades to be SNRF (Sacks *et al.* 2010, p. 1,536).

The three montane subspecies, including the SNRF, are descendants of “nearctic” foxes that first colonized North America from Asia by crossing the Bering Land Bridge prior to the Illinoian glaciation, around 200,000 years ago or earlier (Aubry *et al.* 2009, pp. 2,679–2,682; Perrine *et al.* 2010, p. 5; Sacks 2014, pp. 9–13). When the subsequent and most recent glacial period (the Wisconsinan) began about 100,000 years ago, those foxes established south of the Canadian ice sheets in the area that would become the continental United States (Sacks 2014, p. 10). As average temperatures warmed and the Wisconsinan glaciers retreated about 10,000 years ago, western populations of the nearctic foxes retreated to cold, snowy habitats in the western mountains of the continental United States (Perrine *et al.* 2007, p. 1089). The retreat of the Wisconsinan glaciers was also thought to coincide with a new influx of “holarctic” red foxes across the Bering land bridge and into northwestern North America from Asia (Aubry *et al.* 2009, p. 2,678; Sacks 2014, pp. 12–13), but the genetic evidence of that migration now appears to have resulted from limited interbreeding where the two groups were geographically close, rather than from actual migration (Statham *et al.* 2014, pp. 4,813, 4,820, 4,824–4,825).

### 2.3 Genetics

SNRF in California are genetically distinguishable from lowland California red fox populations using mtDNA comparisons (Perrine *et al.* 2007, pp. 1,089–1,090; Sacks *et al.* 2010, pp. 1,527–1,528; Statham *et al.* 2012, pp. 126–128). One such lowland population, the Sacramento Valley red fox, although related to SNRF from the southern Cascades, is sufficiently distinct as to constitute a separate subspecies: *Vulpes vulpes patwin* (Sacks *et al.* 2010, pp. 1,523, 1,533–1,535). SNRF and Sacramento Valley red foxes are also separated from each other by about 65 km (40 mi) of mid-elevation terrain from which red foxes appear absent (Sacks *et al.* 2010, p. 1,535). Genetic comparisons have shown that other lowland California red foxes living in the San Joaquin Valley, the San Francisco Bay area, and southern California, are descended from a mix of subspecies from several areas, including eastern North America, Alaska, and western Canada, and are thus nonnative in California (Perrine *et al.* 2007, p. 1,090; Sacks *et al.* 2010, pp. 1,527, 1,533). It is also likely that their fur-farm ancestors were subjected to many generations of selective breeding, which could have altered their genomes further as compared to the original wild populations from which they descended (Quinn 2017, p. 2).

Analyses using both mtDNA and microsatellites indicate that red foxes living near Sonora Pass, California, as of 2010 were descendants of the SNRF population that was historically resident in the area (Statham *et al.* 2012, pp. 126–129). This is the only SNRF population known to exist in the Sierra Nevada, and is thus the last known remnant of the larger historical population. The



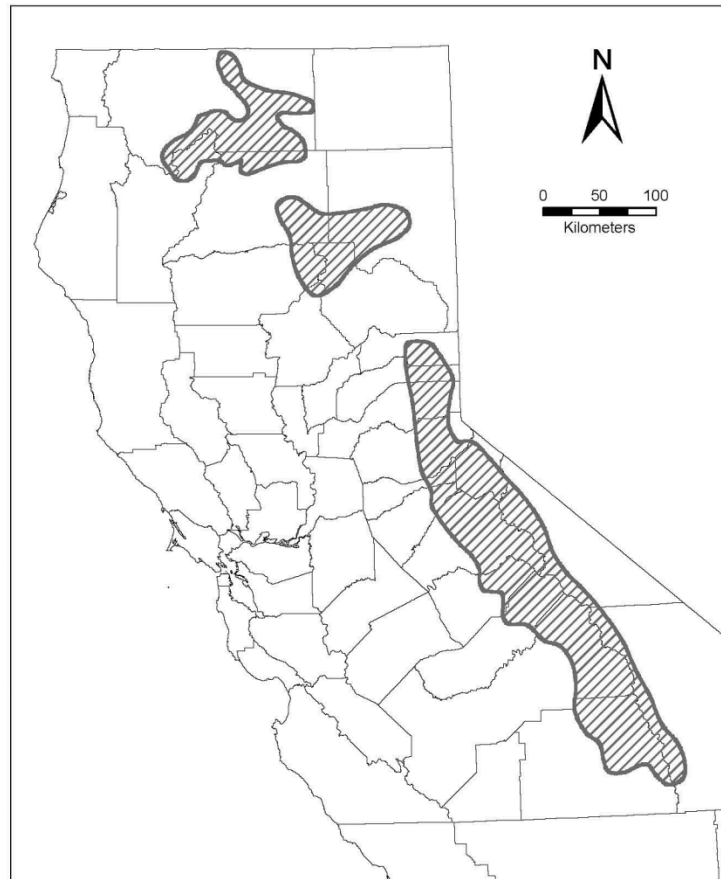
only other SNRF population in California is near Lassen Peak, in the southern Cascades, and shows clear genetic differences from the Sonora Pass population (Statham *et al.* 2012, pp. 129–130). Several black (also called “silver”) and cross fur pattern foxes have also been sighted in the Sonora Pass area but not near Lassen Peak (Statham *et al.* 2012, p. 130; Quinn and Sacks 2014, p. 9). Historically, cross and black fur pattern foxes were much more common in the Sierras (*Id.*).

## 2.4 Demographic Information

Dispersal distances have not been documented for SNRF, but one study found juvenile male red foxes in the American Midwest dispersed 30 km (18.6 mi) on average, while juvenile females dispersed an average of 10 km (6.2 mi) (Statham *et al.* 2012, p. 130). A few young red foxes (5 percent) dispersed over 80 km (50 mi) in their first year (*Id.*).

Home ranges of breeding Sierra SNRF at the Sonora Pass sighting area averaged 910 ha (2,249 ac) (Quinn and Sacks 2014, pp. 2, 11). In contrast, the home range of a collared nonbreeding female at Sonora Pass was 2,980 ha (7,364 ac). Territories of nonbreeding foxes are typically larger than those of breeding foxes, since nonbreeders are free to range farther without the need to revisit a den site (Quinn 2017, p. 2). These territory sizes are large relative to low-elevation red foxes, however (*Id.*), likely due to scarce food resources at higher elevations.

The average lifespan, age-specific mortality rates, sex ratios, and demographic structure of SNRF populations are not known, and are not easily extrapolated from other red fox subspecies because heavy hunting and trapping pressure on those other subspecies likely skew the results (Perrine *et al.* 2010, p. 18). However, three SNRF identified in the Lassen sighting area lived at least 5.5 years (CDFW 2015, p. 2), and a study conducted at the Sonora Pass sighting area found the average annual adult survival rate to be 82 percent, which is relatively high for red foxes (Quinn and Sacks 2014, pp. 10, 14–15, 24).



**Map 1:** SNRF Historical Range in California. Sierra SNRF historical range is southernmost shaded area.

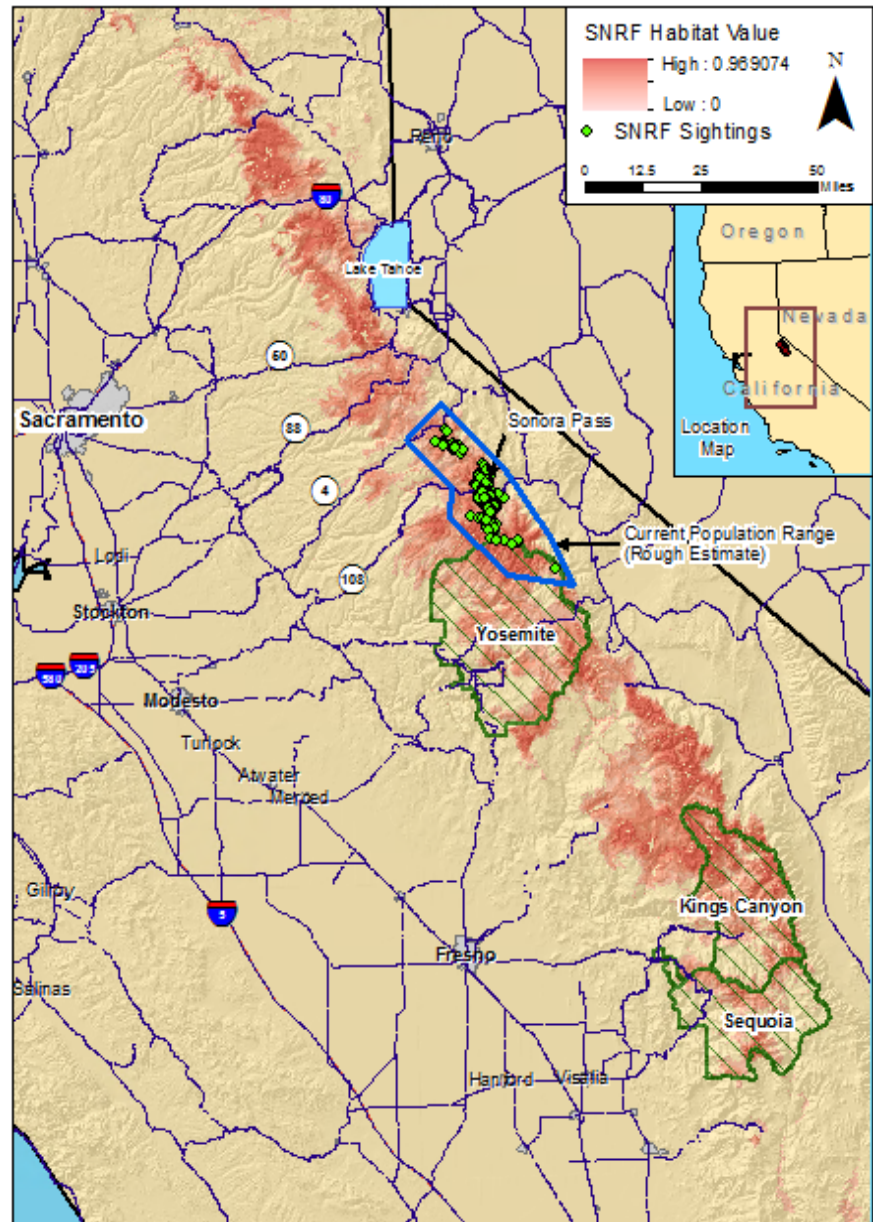
(From Perrine *et al.* 2010, p. 4; based on Grinnell *et al.* 1937, p. 382.)

## 2.5 Range and Distribution

### 2.51 Historical Range and Distribution

Grinnell *et al.* (1937, pp. 381–382) defined the historical range of the SNRF in California as three separate areas (see Map 1, at right). The southernmost area, along the upper elevations of the Sierra Nevada Mountain Range from Tulare to Sierra Counties, constitutes the historical range of the Sierra SNRF.

It remains possible that the Sierra SNRFs historical range may extend slightly into Nevada in places where the eastern Sierras extend past the California border. The Center for Biological Diversity ((CBD) 2011, pp. 8–9) considered the range to extend slightly into Nevada near Lake Tahoe, and redrew the Grinnell *et al.* map (1937, p. 382) accordingly. However, CBD did not specify the information on which they based their revision. That information may be a report of a cross-fur pattern red fox collected in 1934 near Marlette Lake, Nevada (Hall 1946, pp. 229–231; Statham *et al.* 2012, p. 130), which is about 1.6 km (1 mi) east of Lake Tahoe and 8.5 km (5.3 mi) east of the California border, in Washoe County, Nevada at an elevation of 2,389 m (7,838 ft). We consider it likely that this cross-fur pattern fox was a Sierra SNRF, based on the proximity of the sighting to the Sierra SNRF range mapped by Grinnell *et*



**Map 2:** Sierra SNRF Current Range (Cleve *et al.* 2011, fig. 6; Yosemite Conservancy 2017, p. 5; Quinn 2018, attached shapefile).

*al.* (1937, p. 382). The historical range thus likely extends at least 10 km (6.2 mi) into Nevada in that area.

Based on interviews with trappers, Grinnell *et al.* (1937, p. 396) described SNRF population numbers as “relatively small, even in the most favorable territory,” and reported that SNRF likely occurred at densities of 1 per 2.6 square km (1 per square mi). Perrine *et al.* (2010, p. 9) concluded from this that SNRF likely occur at low population densities even within areas of high relative abundance. The large home range estimates discussed under “Demographic Information,” above, further supports the idea that SNRF typically occur at low densities (Quinn 2017, p. 3).

SNRF numbers in California fell considerably in the mid-1900s as compared to trapping data reported by Grinnell *et al.* (1937, p. 389) (Schempf and White 1977, p. 44). The average annual harvest of SNRF pelts in California declined from the 1920s (21 pelts per year) to the 1940s and 50s (6.75 pelts per year) (Grinnell *et al.* 1937, p. 389; Perrine 2005, p. 154). Sightings became rare after the 1940s (about twice per year in the 1950s and 1960s) (Schempf and White 1977, p. 44). The reduced harvest and sightings of SNRF in California led to a prohibition on fox trapping throughout the state in 1974, and to listing of the SNRF as a threatened species under the California Endangered Species Act (CESA) in 1980 (Statham *et al.* 2012, p. 123).

## 2.52 Current Range

We consider SNRF “sightings” to be those records with reliable or independently verified information (such as photographs or genetically tested sample material) showing the location of an SNRF at some point in time. We have characterized the locations of recent sightings (since 2000) into loosely clustered “sighting areas,” two of which are in California. One of these is near Mt Lassen, in the California Cascades, and is part of the Southern Cascades DPS, which extends north into Oregon. The other is in the vicinity of Sonora Pass and northern Yosemite National Park, in the Sierra Nevada Mountains, and constitutes the location of the last known population of the Sierra SNRF (Statham *et al.* 2012, p. 122).

Based on a combination of surveys and Geographic Information System (GIS) analysis of contiguous high-quality habitat (see **2.6 Habitat**, below), the current range of the population runs near the Sierra crest from about Arnot Peak and California State Highway 4 in the north down into Yosemite National Park in the south (Cleve *et al.* 2011, entire; Sacks *et al.* 2015, pp. 10, 14; Eyes 2016, p. 2; Hiatt 2017, p. 1) (see Map 2, above). The population size is estimated at about 10 to 50 adults, including some young adults forgoing potential breeding to help their parents raise their siblings (Sacks 2015, p. 1; Sacks *et al.* 2015, p. 14). This estimate includes hybrids (discussed under **Current Conditions**, below).

All recent sightings of Sierra SNRF in the Sonora Pass area have been on Federal lands (Humboldt-Toiyabe National Forest, Stanislaus National Forest, and Yosemite National Park), in Tuolumne, Mono, and Alpine Counties. An additional reliable sighting of a red fox in 2011 occurred at about 1,500 m (4,921 ft) in Round Valley, California (Inyo County, in or near the Sierra National Forest) about 113 km (70 mi) southeast of the Sonora Pass sighting area, but

within the historical range of the DPS (CDFW 2015, p. 3). This fox may have been in the process of dispersing from the Sonora Pass population (Sacks *et al.* 2015, p. 10).

Although SNRF in northern Oregon have been sighted at elevations only slightly above 1,219 m (4,000 ft) (Aubry *et al.* 2015, entire), Sierra SNRF have consistently been sited at elevations ranging from 2,656 to 3,538 m (8,714 to 11,608 ft) (based on average elevation reported, plus or minus three standard deviations) (Sacks *et al.* 2015, p. 3). SNRF in northern Oregon occupy lower elevations than at Sonora Pass because the higher latitudes in Oregon produce habitat similar to that of the higher elevations in California.

## 2.6 Habitat

Sierra SNRF sightings have consistently occurred in subalpine habitat (Sacks *et al.* 2015, pp. 3, 11). However, based on the behavior of Cascades SNRF discussed below, they would likely enter high-elevation forested habitat as necessary to disperse to new locations. In the Sonora Pass area used by Sierra SNRF, subalpine habitat is characterized by a mosaic of high-elevation meadows, rocky areas, scrub vegetation, and woodlands (largely mountain hemlock (*Tsuga mertensiana*), whitebark pine, and lodgepole pine (*Pinus contorta*)) (Fites-Kaufman *et al.* 2007, p. 475; Sacks *et al.* 2015, p. 11; Quinn 2017, p. 3). Snow cover is typically heavy, and the growing season lasts only 7 to 9 weeks (Verner and Purcell 1988, p. 3). Forested areas are typically relatively open and patchy (Verner and Purcell 1988, p. 1; Lowden 2015, p. 1), and trees may be stunted and bent (krumholtzed) by the wind and low temperatures (Verner and Purcell 1988, p. 3; Sacks *et al.* 2015, p. 11). Map 2, above, shows areas of the Sierras considered to contain high quality habitat based on analysis of SNRF sightings in the Lassen Peak area (Cleve *et al.* 2011, fig. 6; Quinn 2018, attached shapefile).

High-elevation forested habitat below the subalpine zone in the Sierras (and in the southern Cascades near Lassen Peak) consists primarily of red fir forests (*Abies magnifica*), occupying an elevational band across the Sierras from Kern County northwards that runs from about 1,800 to 2,750 m (6,000 to 9,000 ft) (Barrett 1988, p. 3; Perrine 2005, pp. 63–64; Fites-Kaufman *et al.* 2007, p. 458). Sierra red fir forests may also include Jeffrey pine (*Pinus jeffreyi*) and lodgepole pine (Fites-Kaufman *et al.* 2007, p. 456).

A study of Cascades SNRF in the Lassen Peak area documented the migration of several individuals from subalpine regions down into this high-elevation forested habitat during winter (Perrine 2005, pp. 78–79). While on these lower winter ranges, Cascades SNRF at the Lassen sighting area showed a preference for what Perrine (2005, pp. 67, 74, 90) referred to as “mature closed canopy conifer forests.” Cascades SNRF returned to subalpine habitats beginning in spring, but some individuals waited as long as early August (Perrine 2005, p. 160). Similar elevational changes were not observed among the Sierra SNRF at Sonora Pass (Statham *et al.* 2012, p. 130).

The elevational movements observed near Lassen Peak, but not Sonora Pass, may reflect the fact that the Lassen foxes being observed did not breed, and thus were not constrained to year-round territories (*Id.*; Quinn 2017, p. 3). Leporid (rabbit and hare) prey at subalpine elevations in the Lassen area were extremely scarce at the time Perrine conducted his study (Perrine 2005, p. 2;

Rich 2014a, p. 1; Sacks *et al.* 2015, p. 24). It is possible that this may have influenced the Lassen foxes decision to forego breeding and migrate to lower elevations. Leporids have since returned to the Lassen area in greater numbers (Sacks 2017, p. 2), but we are not aware of any studies indicating whether this has affected SNRF elevational migrations.

## 2.7 Feeding

Like other red foxes in North America, Sierra SNRF appear to be opportunistic predators of small mammals such as rodents (Perrine *et al.* 2010, pp. 24, 30, 32–33; Cross 2015, p. 72). Leporids such as snowshoe hare (*Lepus americanus*) and white-tailed jackrabbit (*Lepus townsendii*) are also an important food source for Sierra SNRF, particularly in winter and early spring (Aubry 1983, p. 109; Rich 2014a, p. 1; Quinn 2017, pp. 3–4; Sacks 2017, p. 3).

Whitebark pine seeds may also be an important food source, particularly in winter (Sacks *et al.* 2017, p. 2). These seeds are collected and stored in caches by red squirrels (*Tamiasciurus Hudsonicus*) in the Rocky Mountains (Cross 2015, p. 78), and by Clark's nutcrackers in the Sierra Nevada (Fites-Kaufman *et al.* 2007, p. 478). Cross (2015, p. 71) found that in the winter of 2013, 14 of 30 scats from montane foxes (*Vulpes vulpes macroura*) in Yellowstone National Park, Wyoming, included whitebark pine seed remains; and that those remains made up a maximum of 97 percent, and an average of 61 percent of the material in those scats. The percent frequency of occurrence of whitebark seed remains for that winter was approximately twice that of other food sources (considering small rodents as a single food source) (*Id.* at 73). Whitebark pine seeds also occurred in 5 of 13 red fox scats during the summer, comprising an average of 20 percent and a maximum of 40 percent of the scat material where found (*Id.* at 73). Scats sampled the following year showed only a trace amount of whitebark pine seed consumption, however (*Id.* at 72–73), so the relative importance of this food source appears to be highly variable—presumably due to changes in the abundance of whitebark pine seeds relative to other food sources from year to year (see 3.1 Habitat Characteristics Affecting Viability, below) (*Id.*).

Whitebark pine seeds are rich in both protein and fats (Fites-Kaufman *et al.* 2007, p. 478), and thus are likely to be an important food source where available, particularly in subalpine habitat where primary productivity is low and winter food sources are scarce (Perrine 2005, p. 150). Whitebark pine is the most widespread treeline conifer in the Sierras, and occurs in the Sierra SNRF's current range, and throughout the vast majority of the Sierra SNRF's historical range, from the Lake Tahoe area south to Mt. Whitney in Sequoia National Park (Fites-Kaufman *et al.* 2007, pp. 477–478).

## 2.8 Reproduction and Life History

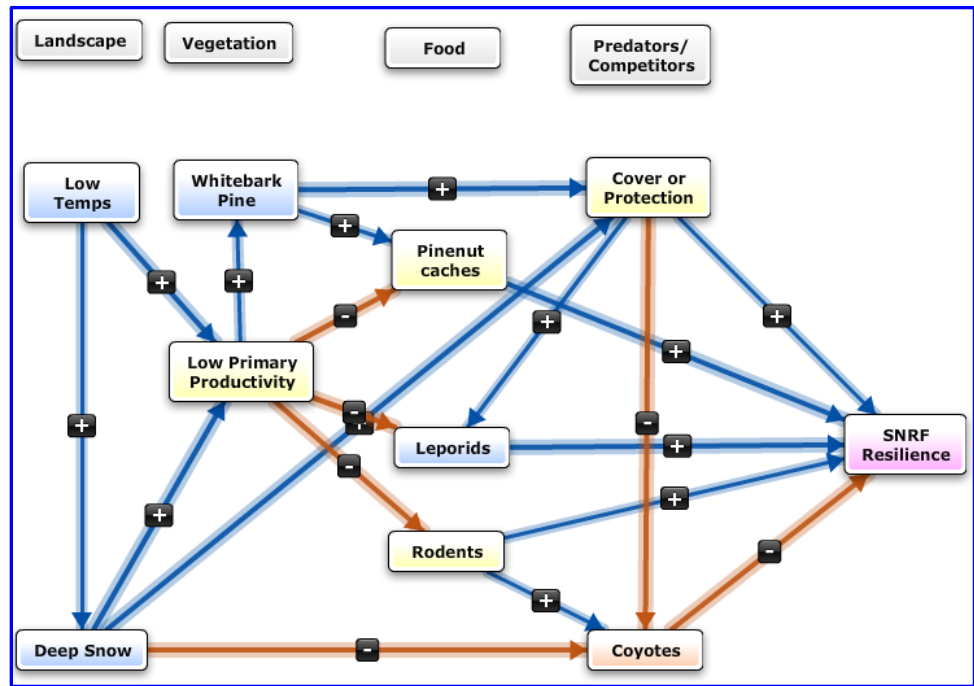
Although little direct information exists regarding Sierra SNRF reproductive biology, we have little evidence to suggest it is markedly different from lowland dwelling North American red fox subspecies (Aubry 1997, p. 57). The most likely possible exception is that the Sierra SNRF reproductive cycle may be somewhat delayed so that pup-raising can coincide better with increased resources available in spring (Quinn 2017, p. 4). Other North American subspecies are predominately monogamous and mate over several weeks in the late winter and early spring (*Id.*). The gestation period for red fox is 51 to 53 days, with birth occurring from March through

May in sheltered dens (Perrine *et al.* 2010, p. 14). Sierra SNRF use natural openings in rock piles at the base of cliffs and slopes as denning sites (Grinnell *et al.* 1937, p. 394). They may possibly also dig earthen dens, similar to Cascade red foxes (*Vulpes vulpes cascadiensis*), though this has not been directly documented in Sierra SNRF (Aubry 1997, p. 58; Perrine 2005, p. 153). Litter sizes of two to three appear to be typical (Perrine 2005, p. 152). Reproductive output is generally lower in montane foxes than in those living at lower elevations, possibly due to comparative scarcity of food (Sacks 2017, p. 2; Perrine 2005, pp. 152–153). Red fox pups in general are typically weaned by 8 to 10 weeks of age, begin exploring their parents’ home range by 12 weeks (June through August), and disperse in the early fall when fully grown (Perrine *et al.* 2010, pp. 14–15). Some individuals may remain with their parents for an extra year, however, to help raise their parents’ next litter. Such “helpers” are not uncommon in other red fox subspecies (Sacks 2015, p. 1; Wildlife Online 2015, p. 60;), and several cases of a daughter staying on her parents’ territory after her first year are documented (Quinn 2017, p. 4).

### 3.0 Characteristics Affecting Viability in the DPS

This section discusses environmental and demographic characteristics affecting Sierra SNRF viability and ability to persist into the future.

When the environmental characteristics of an existing population are not sufficiently conducive to viability, the resiliency of the population is affected (see “resiliency” definition, Section 1.0, above). A lack of areas supporting such characteristics may also affect the ability of the DPS to establish redundant and representative populations, but we address such population issues as primarily involving demographic issues.



**Figure 1:** Interplay of environmental characteristics affecting viability in Sierra SNRF

For a summary of the environmental and demographic characteristics affecting the viability of the DPS, addressed in terms of effects on resiliency, redundancy, and representation, see Table 1 under **6.0: Summary of Current and Future Viability**, below.

Note that the ESA requires consideration of five factors when making listing determinations. In broad terms, those factors include issues relevant to habitat; overutilization for commercial, recreational, scientific, or educational purposes; disease or predation; existing regulatory mechanisms, and other natural or manmade factors affecting the continued existence of the species. The environmental characteristics affecting the Sierra SNRF's viability discussed below all fall into either the habitat or "other" factor categories. We address relevant existing regulatory mechanisms in Section 6.0, below, but do not consider any such mechanisms to negatively affect the viability of the Sierra SNRF. We do not address issues of overutilization because we lack evidence that this is affecting viability. As discussed in Section 6, hunting and trapping of red foxes (two of the most common causes of overutilization) are specifically precluded by state law.

### **3.1 Environmental Characteristics Affecting Viability**

#### Subalpine habitat (Low temperatures, low primary productivity)

Although SNRF in general are able to disperse through upper montane forest habitat (Perrine 2005, pp. 2, 78), they are only known to establish territories and raise pups in subalpine habitat (Sacks *et al.* 2015, p. 3). Even nonreproducing Cascades SNRF that descended into upper montane forest habitat during winter, returned to subalpine habitat during spring or summer (Perrine 2005, pp. 78–79).

A likely reason for this observed dependence on subalpine habitat is that the low temperatures, short growing season, and consequent low primary productivity of subalpine regions (Verner and Purcell 1988, p. 3; Cross 2015, p. 77) make rodent prey populations less abundant, which in turn causes coyotes to occur at lower densities in subalpine regions than at lower elevations (Cross 2015, p. 43).

Coyotes can exclude red foxes from raising families in certain areas by chasing and killing them (Voigt and Earl 1983, pp. 852, 856; Perrine 2005, pp. 36, 55; Perrine *et al.* 2010, p. 17; Sacks *et al.* 2015, p. 3). Studies in North Dakota and eastern Maine show red foxes coexisting with coyotes by establishing home ranges that only partially overlap coyote home ranges – extending into areas unfrequented by coyotes (Sargeant *et al.* 1987, p. 288; Harrison *et al.* 1989, p. 183). As coyote density increases the risk of interspecific conflict also tends to increase (Sargeant *et al.* 1987, p. 292). Thus, increased coyote density on a given landscape can lead to decreased density of foxes (Sargeant *et al.* 1987, p. 288; Harrison *et al.* 1989, p. 185).

The current and historical ranges of coyotes overlap the current and historical ranges of the Sierra SNRF, but fewer coyotes per square kilometer occur in subalpine habitat than at lower elevations (Quinn 2017, p. 5; Sacks 2017, p. 2). This may be due to low productivity and deep snow in subalpine areas (see below) (Sacks 2017, p. 2). The relative lack of coyotes may in turn have made subalpine areas attractive for Sierra SNRF, leading in turn to evolutionary adaptations in SNRF such as warmer coats, furred paw pads, and lower body weights allowing them to move more efficiently over snow (Quinn 2017, p. 5; Sacks 2017, p. 2). The generally low primary productivity of subalpine habitat also likely explains the historically lower densities of SNRF compared to lowland red foxes (Sacks 2017, p. 2).

## Deep Winter and Spring Snowpacks

Coyotes' greater mass and higher foot loading leaves them less able than SNRF to move efficiently over deep snow (Perrine 2005, p. 81). Accordingly, resident coyotes overwintering in subalpine habitat are likely to have their competitive dominance reduced by higher snowpacks during any given year (Sacks 2017, p. 3). They are also likely to restrict home ranges to areas of lower or more compact snow, thereby establishing lower densities and leaving more areas outside coyote home ranges for SNRF to utilize (Dowd *et al.* 2014 p. 39; Quinn 2017, p. 5). Deeper snowpacks over several years can also decrease subalpine coyote densities by making such habitat less inviting to new arrivals (Sacks 2017, p. 3). Shallow snowpacks over several years can produce the opposite results: increasing coyote densities by allowing easier movement in the area for new arrivals. Sierra SNRF births likely occur from March through May (Perrine *et al.* 2010, p. 14), so deep snowpacks could be an important factor helping to buffer SNRF from coyote interference during pupping season in particular. Sierra snowpacks are typically highest around April 1<sup>st</sup> (Kadir *et al.* 2013, p. 77).

## Rodent Prey

Although montane red foxes are opportunistic feeders, and eat carrion and vegetable matter such as berries and pine seeds in addition to meat, their primary food source consists of small mammals, including rodents (Perrine *et al.* 2010, p. 24; Cross 2015, p. 72). Important prey genera include gophers (*Thomomys* sp.), deer mice (*Peromyscus* sp.), voles (*Microtus* sp.), and ground squirrels (*Spermophilus* sp.) (*Id.*).

Potential stressors that could affect rodent prey availability to SNRF include competition from coyotes, and compaction of snow by snowmobiles, potentially affecting subnivean rodents burrowing below the snow surface.

## Leporid Prey

The Leporidae family includes rabbits and hares. Snowshoe hares (*Lepus americanus*) and white-tailed jackrabbits (*L. townsendii*) are both prey items of SNRF that are present in the Sierras. The snowshoe hare of the Sierras (*Lepus americanus tahoensis*) is a separate subspecies from those found in the vicinity of Mt. Shasta and the Trinity Mountains (*L.a. klamathensis*) (CDFW undated, p. 2). Leporids are large-bodied relative to other winter and spring small mammalian prey, thereby providing greater energetic return per kill than smaller prey. Such energetic efficiency can be especially important during gestation and lactation. Additionally, because of their smaller bodies and lighter foot-loading, SNRF are more able than coyotes to pursue leporids running over deep snow (Perrine 2005, p. 193). Leporids are thus likely to constitute a significant, potentially keystone winter prey source (Sacks 2017, p. 3; Sacks *et al.* 2015, p. 15).

Although little is known about the population dynamics of leporids in the Cascade and Sierra Nevada Ranges, in boreal systems their populations are known to fluctuate, periodically reaching high-densities that fuel demographic increases of predator populations (Sacks 2017, p. 3).



Studies of montane red foxes in the Washington Cascades and Rocky Mountains determined that snowshoe hares were among the most important and commonly taken winter prey items (Aubry 1983, p. 109; Cross 2015, pp. 72–73). In contrast, a study of Cascades SNRF near Lassen Peak documented a general lack of leporid prey during snowy months in the area at that time (Perrine 2005, p. 35). The Lassen study documented the descent of several SNRF individuals to comparatively lower elevations during the winter, as well as the failure of those individuals to reproduce (Perrine 2005, pp. 35, 162). Such seasonal migrations are generally uncharacteristic of red foxes, and may therefore have been prompted by the lack of leporid prey during the study (Sacks 2017, p. 4). Low leporid numbers also correlate with low reproduction in other mesocarnivores, such as coyote and lynx, at high-latitudes (O’Donoghue *et al.* 1997, pp. 158–159), and so may have played a causal role in the foxes’ failure to reproduce (Quinn 2017, p. 6). A study of Sierra SNRF at Sonora Pass, where snowshoe hare and white-tailed jackrabbits are both present (Rich 2014a, p. 1), found evidence that the foxes stayed in their high-elevation subalpine areas during winter rather than descending to lower elevations (Sacks *et al.* 2015, p. 11).

### Whitebark Pine

As discussed under **Feeding**, above, whitebark pine seeds are likely to constitute an important winter food source during some years. Whitebark pines limit predation on their seeds by producing large numbers of seeds in some years and very few in other years (Cross 2015, p. 78). This strategy is called mast seeding, and tends to discourage seed predators from establishing large populations near the trees and thereby consuming most of the seeds (*Id.*). SNRF would be well-positioned to benefit from high pine seed production during those years in which it occurs, potentially leading to increased reproductive success in those years.

## **3.2 Demographic Characteristics Affecting Viability**

### Population Size:

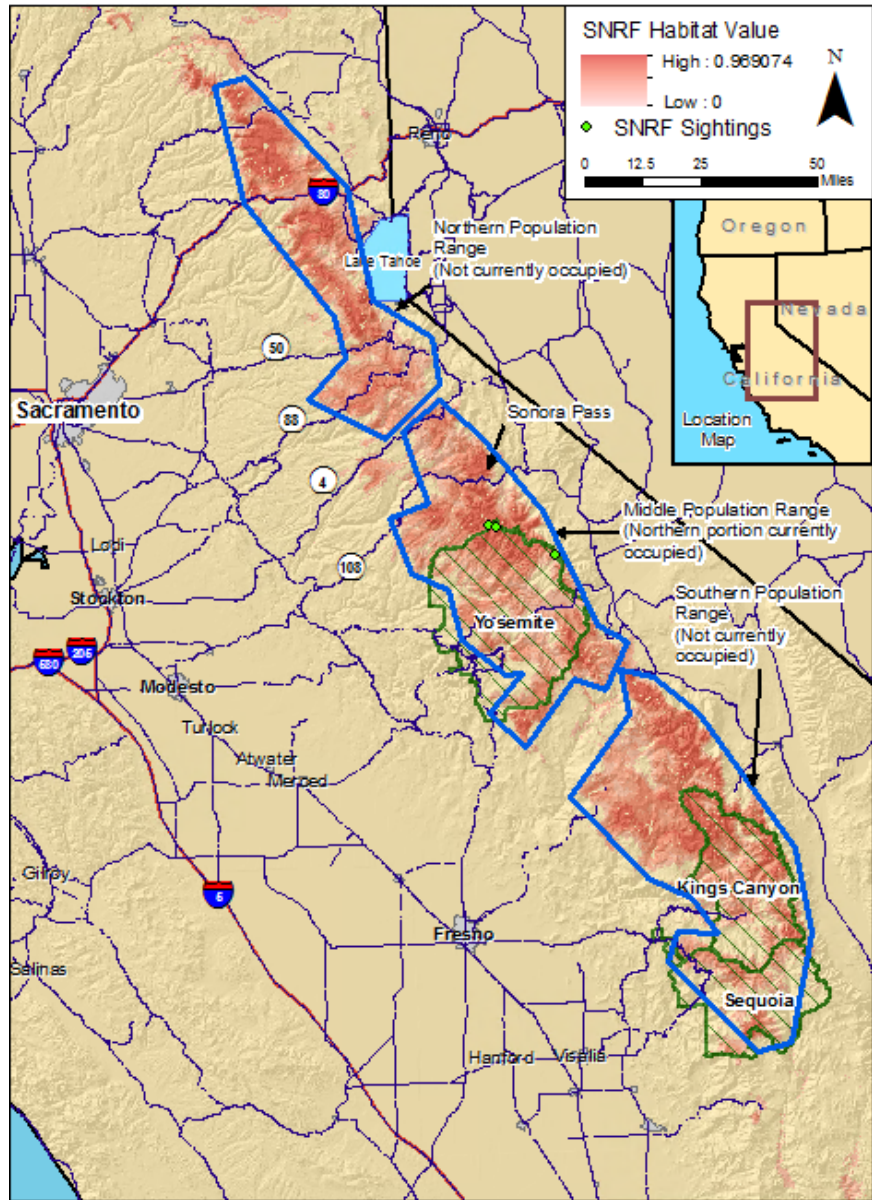
To be viable and resilient, a population needs to maintain a certain minimum size (Gilpin and Soulé 1986, entire). Populations below their minimum viable size are susceptible to extirpation from inbreeding depression, or from deleterious chance events such as droughts or diseases (*Id.* at 20–21). Inbreeding depression is caused by the chance loss of beneficial gene variants (alleles) in small populations, leaving deleterious alleles as the only remaining variants of a given gene (Soule 1980, pp. 157–158). It also results from increased mating between closely related individuals in small populations, thereby increasing the likelihood that both parents pass on the same recessive deleterious alleles to their young (Lande and Barrowclough 1987, p. 96). It can result in abnormal sperm, congenital defects, and lowered disease resistance (Soulé 1980, pp. 157–158; Gilpin 1987, p. 132; O’Brien 2003, pp. 62–63).

To avoid inbreeding depression, in general, a population typically requires an “effective” population size of at least 100 reproducing adults (Frankham *et al.* 2014, p. 58). The “effective size” of a population (“ $N_e$ ”) refers to the number of breeding individuals in an “ideal” population (with characteristics that minimize loss of alleles) (Lande and Barrowclough 1987, pp. 88–89). Because most populations lack many of the characteristics of ideal populations, the actual

(census) size of a population (“N”) is often much greater than its effective size. Various estimates of  $N_e$  as compared to  $N$  across different species range from averages of 0.10 to 0.19 (Palstra and Ruzzante 2008, p. 3,431; Frankham *et al.* 2014, p. 60), and medians of 0.12 to 0.23 (Palstra and Fraser 2012, p. 2,360; Frankham *et al.* 2014, p. 60).

We are not aware of any studies establishing minimum viable sizes for populations of montane red fox or of any other red fox subspecies. In lieu of any additional information to help identify what a minimum viable population size may be for the Sierra SNRF, we look to a recent population viability analysis (PVA) of a related canid, the Catalina Island fox (*Urocyon littoralis catalinae*) from Santa Catalina Island, California. The Catalina Island fox PVA identified 150 individuals as the minimum required to safely survive deleterious chance events (Kohlmann *et al.* 2005, p. 77). If Sierra SNRF were also to maintain a similar census population size, as well as the minimum required effective population size of 100 discussed above, then its ratio of  $N_e$  to  $N$  would be 0.67. This is well above the general range of such ratios discussed above (0.10 to 0.23), and thus a possible conservative estimate of the minimum census population size required for resiliency in Sierra SNRF populations. Although the Catalina Island fox occurs in a different ecosystem (with different food habits and prey availability), we nevertheless adopt this estimate of 150 individuals here as the best-supported minimum viable census population size for Sierra SNRF, given that island foxes and SNRF are fairly closely related species with

in a different ecosystem (with different food habits and prey availability), we nevertheless adopt this estimate of 150 individuals here as the best-supported minimum viable census population size for Sierra SNRF, given that island foxes and SNRF are fairly closely related species with



**Map 3:** Sierra SNRF Potentially Suitable Habitat for a Larger or Additional Populations (Quinn 2018, attached shapefile; Yosemite Conservancy 2017, p. 5).

in a different ecosystem (with different food habits and prey availability), we nevertheless adopt this estimate of 150 individuals here as the best-supported minimum viable census population size for Sierra SNRF, given that island foxes and SNRF are fairly closely related species with

similar reproductive practices. Like SNRF, island foxes are monogamous, breed once a year in spring, and produce litters averaging two to three pups (NPS 2017, pp. 3–4).

We therefore consider populations of Sierra SNRF with roughly 150 or more adult individuals likely to survive chance deleterious events, whereas stochastic events become an increasing risk to viability as population numbers dip below 150.

Note that this issue of minimum viable population size addresses the resiliency of a given population, as do all of the environmental characteristics affecting viability discussed above. Additional demographic characteristics affecting viability, discussed below, address redundancy or representation in the DPS as a whole.

### Number of Populations

As discussed above (Section 1.0), range-wide viability is improved by multiple populations (redundancy) or single large populations spread across a species range, so that loss of a single population or group of individuals within a large population due to catastrophic events (or simply low resiliency) does not result in loss of the entire DPS (Wolf *et al.* 2015, p. 204). When we determined that listing the Sierra SNRF was warranted, we also determined that listing the other DPS—Cascades SNRF—was not warranted (80 FR 60990). We based our finding regarding the Cascades SNRF, in part, on the fact that it had “at least one small population at the southern end of its range, and an unknown number of populations of unknown size throughout the remainder of the DPS’s range” (80 FR 61016). Since the gap between the northernmost Cascades SNRF sighting area and the next one south is much larger than the gaps between other sighting areas in Oregon, it is most likely that the unknown number of populations in Oregon is at least two, and that the entire DPS therefore has at least three populations (including the one in California near Lassen Peak) (USFWS 2015 [spp rpt], pp. 12, 38; Sacks *et al.* 2017, p. 2). We therefore consider that the Sierra DPS could persist following catastrophic events through either presence of multiple resilient populations distributed throughout the historical range (i.e., the redundancy aspect of viability) or a single large, wide-ranging population in the Sierra Nevada. We identify likely habitat that could support a larger or additional populations in Map 3, above. Note that the blue polygons are intended to show general areas that could support more Sierra SNRF individuals or populations; they do not indicate that any given population should occupy an entire polygon.

Population Locations Representative of the Range: As discussed above (Section 1.0), viability improves when populations are representative of the ecological variation across the range. In the case of the Sierra SNRF, much of that ecological variation is caused by differences between the northern, central, and southern portions of the range. For instance, the jet stream typically crosses northern California and the Pacific Northwest, resulting in a pattern of decreasing annual precipitation in the Sierras from north to south (Fites-Kaufman *et al.* 2007, p. 458). Latitudinal differences also produce cooler temperatures in the north than in the south for a given elevation (*Id.*). In contrast, maximum elevations run from about 3,000 m (9,800 ft) around Lake Tahoe in the north to about 4,000 m (13,000 ft) in Sequoia National Park in the south (*Id.*) allowing subalpine habitat to run the extent of the range, despite subtle differences in that habitat caused by differences in precipitation and elevation. Vegetation differences also follow this gradient.

Whitebark pine is more dominant in the north, but shares habitat with limber pine (*Pinus flexilis*) in the central Sierras and foxtail pine (*Pinus balfouriana*) in the south (*Id.* at 475).

The Sierra SNRF historically occurred across all these ecological variations within the Sierra Nevada mountain range. A larger single Sierra SNRF population extending north or south, or additional populations in the northern, middle, and southern portions of the range would contribute to the DPS's ability to adapt to changing environmental conditions over time (i.e., the "representation" aspect of viability (see section 1.0, above)), and restore greater genetic variability and range of local adaptations to the DPS.

Map 3 (above) identifies generalized locations of potentially suitable habitat for multiple populations (or for a larger population). Map 3 also identifies the current, small population. As with Map 2, the locations indicate broad areas within which SNRF could occur, and are not meant to imply that a population should occupy an entire polygon.

Genomic Integrity: The "Representation" aspect of viability includes maintaining the genetic diversity and distinctiveness of Sierra SNRF. Maintaining a representative genetic Sierra SNRF population(s) precludes a high amount of genetic introgression into the SNRF population from other fox populations. Nonnative genes, introduced through hybridization with non-SNRF individuals, can lower survivorship or reproductive success by interfering with adaptive native genes or gene complexes (Allendorf *et al.* 2001, p. 617; Frankham *et al.* 2002, pp. 386–388). Continued interbreeding with nonnatives, particularly when combined with low reproductive success among native mated pairs, can cause the complete replacement of native genes by their nonnative counterparts (genetic swamping) (Cahill *et al.* 2013, p. 4; Sacks *et al.* 2015, pp. 17–18). Such genetic swamping would effectively transform the population from SNRF to some other subspecies.

### **3.3 Other Characteristics Affecting Viability**

#### Disease

Diseases most likely to have population-level effects on red foxes include sarcoptic mange, canine distemper, and rabies (Perrine *et al.* 2010, pp. 17, 28). Sarcoptic mange is a skin disease transmitted by a parasitic mite that leads eventually to weight loss and death (Baldwin 2011, p. 1). Major outbreaks leading to losses or near losses of entire populations of red fox have been documented in Bristol, England in 1994 (Baldwin 2011, p. 1), and in northern Sweden in the late 1970s and early 1980s (Danell & Hornfeldt 1987, p. 533). The mite can be carried by coyotes and domestic dogs, in addition to red fox (Baldwin 2011, p. 13). Canine distemper is a highly contagious viral disease attacking the animal's central nervous system (Granberry 1996, p. 2). In addition to red foxes, it can affect dogs, coyotes, grey foxes, raccoons, and skunks, and is 90 percent fatal to wildlife (*Id.*). Rabies is a viral disease of the central nervous system, usually transmitted by bite (CDC 2013, p. 1). Death rate for red foxes infected by rabies is high, even when receiving low dilutions of the virus (Black and Lawson 1970, p. 311).

### **4.0 Current Conditions**

In this section we address the extent to which the current conditions of the Sierra SNRF are similar to the characteristics indicative of viability, as discussed above in Sections 3.1–3.3.

#### 4.1 Current Condition of Environmental Characteristics Affecting Viability

Subalpine habitat and coyote presence: Over the past 100 years, average temperatures in alpine regions have increased by 0.3 to 0.6°C (Perrine *et al.* 2010, p. 30). In the Lake Tahoe region (northern Sierras), the average number of days per year for which the average temperature was below-freezing has decreased from about 79 in 1910 to about 51 in 2010 (Kadir *et al.* 2013, p. 102).

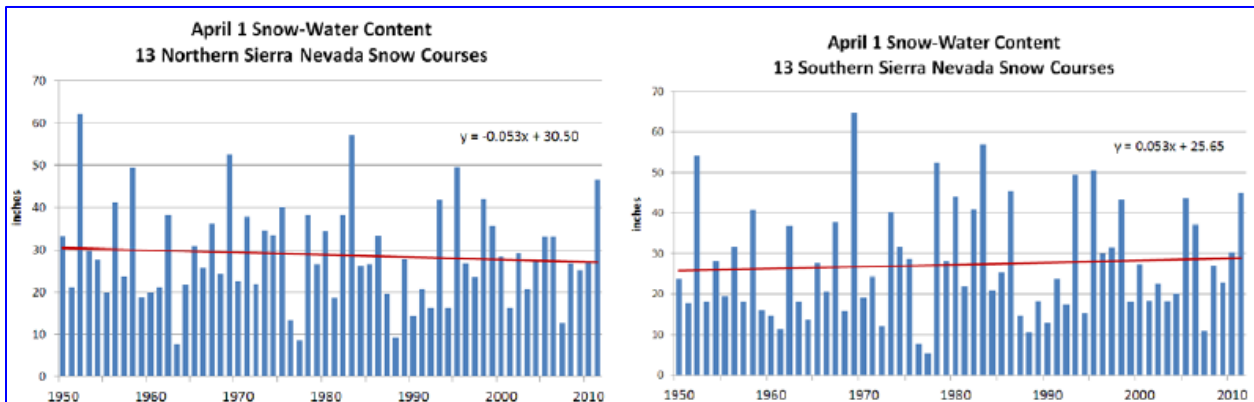
Increasing temperatures may have increased the productivity of high-elevation areas, allowing them to support more coyotes in spring and summer months. Direct measurements of primary productivity on a subalpine meadow in Yosemite National Park have shown that mesic (medium wet) and hydric (wet) meadows both tend to increase productivity in response to warmer, drier conditions (Moore *et al.* 2013, p. 417). Xeric (dry) meadows tend to increase productivity due to warmth, but decrease due to drier conditions (*Id.*). A comparison of tree biomass and age in subalpine forests now and about 75 years ago also points to increased productivity (Kadir *et al.* 2013, p. 152). Specifically, small trees with comparatively more branches increased by 62 percent, while larger trees decreased by 21 percent, resulting in younger, denser stands (*Id.*). This overall increase in biomass occurred consistently across the subalpine regions of the Sierras and across tree species. The primary cause was an increase in the length of the growing season (*Id.*).

Increases in primary productivity can produce shifts in the ranges of small mammals, including rodents (Kadir *et al.* 2013, pp. iv, 176). This has not yet resulted in new species entering the current elevational range of Sierra SNRF (2,656 to 3,538 m (8,714 to 11,608 ft)), but it has resulted in the loss or diminished presence of several small rodent species in that range (as studied in the Yosemite area) (Kadir *et al.* 2013, p. 176). Small rodents no longer in the SNRF's elevational range include Allen's chipmunk (*Tomas senex*) and bushy tailed-woodrat (*Neotoma cinerea*), while rodents with reduced elevational overlap with SNRF include alpine chipmunks (*Tamias alpinas*) and American pika (*Ochotona princeps*) (Moritz *et al.* 2008, p. 263; Kadir *et al.* 2013, p. 176). It is not clear to what extent rodent species that have remained present may have increased in number, though we consider some such increases to be likely due to increased primary productivity.

Based on recent surveys, coyotes are present in the Sonora Pass area at the same elevations as SNRF during the summer months, although the average elevation for coyotes appears to be lower than average elevation for SNRF (Quinn and Sacks 2014, pp. 11, 35). Coyotes also appear to outnumber SNRF in the area (*Id.* at 12). From 2011 to 2013, genetic tests of scats found in the area of a study on SNRF (a subset of the entire area considered potentially capable of supporting SNRF) identified 31 individual coyotes, but only 24 SNRF (including 6 hybrid pups of SNRF and nonnative males) (*Id.* at 2, 12). Four coyotes were present for 1 year or longer, and were therefore likely resident (*Id.* at 12). Several of the coyotes were related to each other, suggesting they were establishing territories and raising pups (*Id.*). One such breeding pair was located in early April 2013 (during SNRF pup-rearing season) at an elevation of 3,000 m (9,843 ft).

Additional monitoring subsequent to 2014 documented a coyote den with pups above 2,896 m (9,000 ft), and genetic evidence of stable family groups in the region over multiple years (Quinn 2017, pp. 6–7). Coyote densities therefore appear to have increased in the region relative to historical levels. This may in part result from increased productivity due to climate changes, although snowpack levels were low during much of the monitoring period due to drought, and this may also have affected coyote densities (*Id.*) (see below).

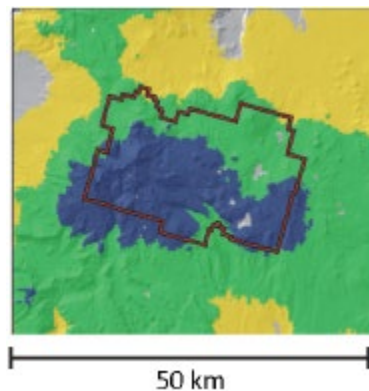
Deep Winter and Spring Snowpacks: Over the past 50 years, warming temperatures have led to a greater proportion of precipitation falling as rain rather than snow, earlier snowmelt, and a decrease in snowpack throughout the western United States generally (Kapnick and Hall 2010, pp. 3,446, 3448; Halofsky *et al.* 2011, p. 21). This is true of the northern Sierras, where the



**Figure 2:** Snowpack water content in the northern and southern Sierras, 1950–210 (from Kadir *et al.* 2013 p. 76).

average snow-water equivalent (SWE) of the snowpack decreased from 79 to 66 cm (31 to 26 in) between 1950 and 2010 (Kadir *et al.* 2013, p. 76). The southern Sierras, however, show a trend in the opposite direction: increasing average SWE from 66 to 74 cm (26 to 29 in) over the same time period (*Id.*). The increase in the southern Sierras is partly due to their increased elevation, resulting in more precipitation falling as snow rather than rain in the upper reaches. A change in climate conditions has also produced an increase in overall precipitation in the southern Sierras (Mote 2006, p. 6,219).

Figures 3a through 3c (at right and next page) show current April 1<sup>st</sup> SWE levels in national parks representative of the northern, central, and southern portions of the Sierra SNRF’s historical range. Lassen Volcanic

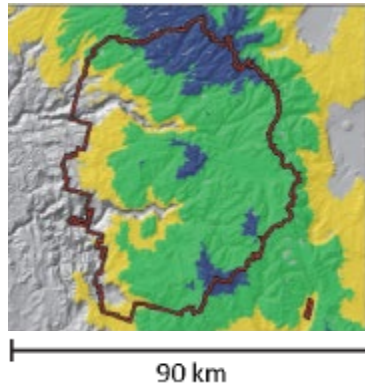


**Figure 3a:** Current Lassen Nat’l Park Snowpack Levels (1981–2010) April 1 SWE, mm  
 0 - 100      100 - 400  
 400 - 1,000      1,000 - 1,500  
 (from Curtis *et al.* 2014, p. 11)

National Park (Figure 3a) is actually in the southern Cascades, but it is only about 50 km (31 mi) north of the northern Sierras, and so is likely to have similar snowpack levels. One of several

Cascades SNRF populations occurs there, but it is the southernmost population of the Cascades DPS, rather than part of the Sierra DPS (80 FR 61011).

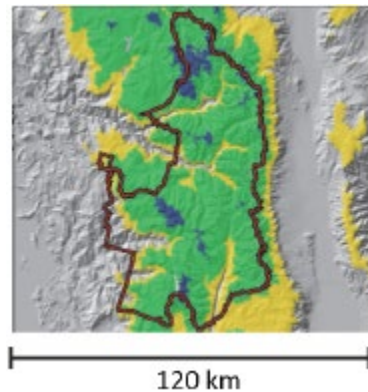
In the central Sierras, average current April 1<sup>st</sup> snowpack levels in Yosemite (which overlaps the current SNRF population location) have been just above 600 mm (23.6 in) (Curtis *et al.* 2014, p. 9). These averages include the entire park, so higher



**Figure 3b: Current Yosemite Snowpack Levels (1981–2010)**  
 April 1 SWE, mm  
 0 - 100      100 - 400  
 400 - 1,000      1,000 - 1,500  
 (from Curtis *et al.* 2014, p. 11)

historical snowpack levels have been common in certain areas (Figure 3b). To date, all Sierra SNRF individuals sighted within the park have been in the areas of highest snowpack, as indicated by the northern blue region in Figure 3b (Eyes 2016, p. 2).

In the southern Sierras, as represented by Sequoia/Kings Canyon, average snowpack levels have been about 600 mm SWE (23.6 in) (Curtis *et al.* 2014, p. 9). The distribution of snowpack depths within the parks, around that average, is shown in Figure 3c.



**Figure 3c: Current Sequoia / Kings Canyon Snowpack Levels (1981–2010)**  
 April 1 SWE, mm  
 0 - 100      100 - 400  
 400 - 1,000      1,000 - 1,500  
 (from Curtis *et al.* 2014, p. 11)

These graphics are representative of “average” years, so snowpacks would be lower during droughts, such as the recent severe drought from 2012 through 2016 (Kim and Lauder 2017, pp. 3–44). During the winter ending in 2014, snowpacks were so low that snowmobile use at the Bridgeport Winter Recreation Area (BWRA, the large white area south of CA Highway 108 in Map 4, below) was largely discontinued (USFS 2010, pp. 17–20; Rich 2014a, p. 1). This drought and resulting unusually low snowpack may have been a factor influencing the presence of resident coyotes in the Sonora Pass area, as discussed above. The seriousness and extent of such droughts is exacerbated by potential adverse effects associated with changing climate conditions (Ault *et al.* 2014, pp. 7,529–7,530).

The current condition for deep winter snow might thus be summarized as generally good, but subject to bad years during droughts. The differences between southern and northern Sierra

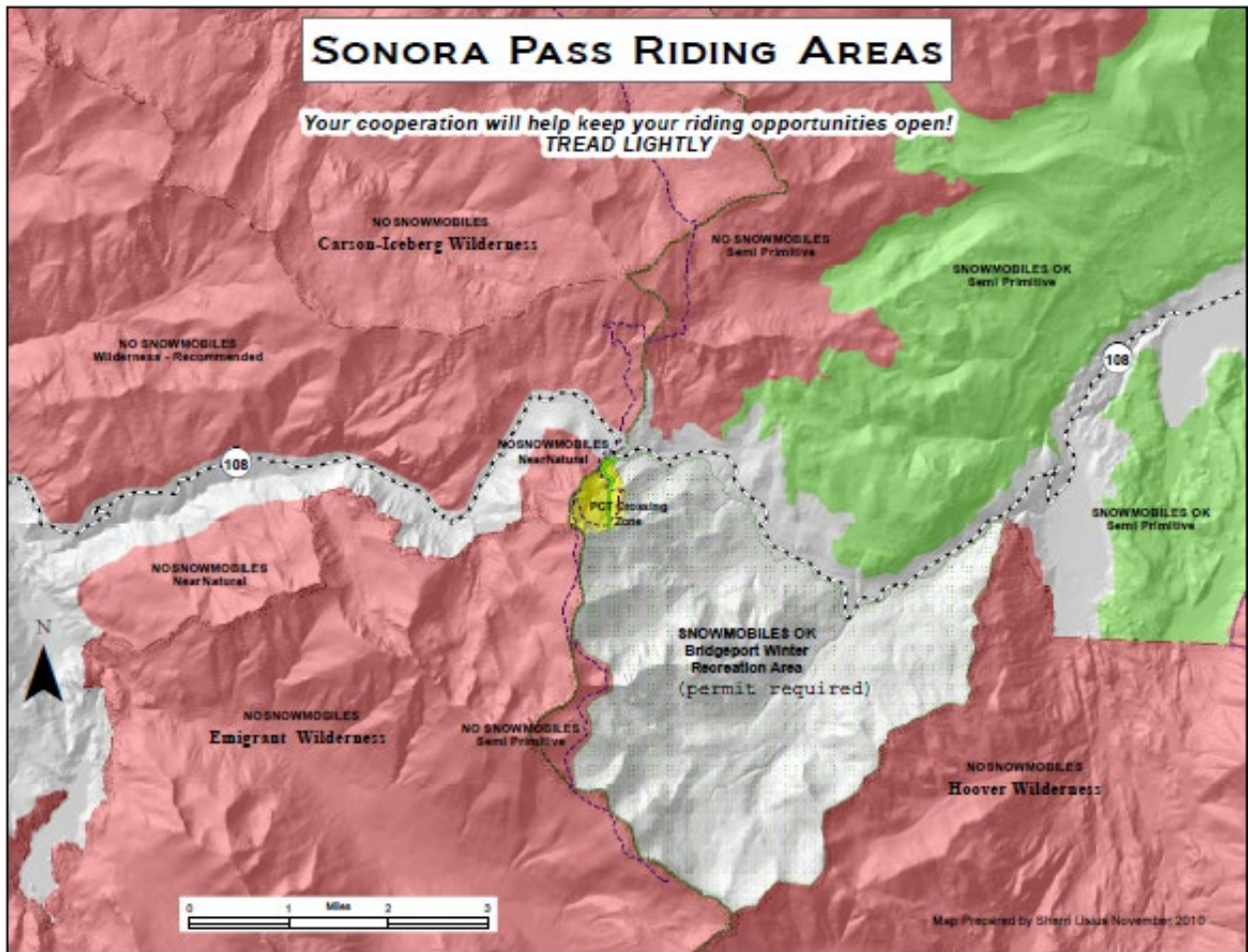
snowpacks would not have a significant effect on the current population at Sonora Pass, which is in the middle of the range.

Rodent Prey: As discussed above (under the Subalpine habitat and coyote presence discussion at the beginning of Section 4.1), rodent population numbers in subalpine areas have likely increased somewhat due to increased primary productivity. However, there are several factors that may limit their availability to SNRF in specific areas:

- Increased presence of coyotes, to the extent that this is occurring, may tend to exclude SNRF from the better hunting areas.
- Snowmobile traffic compacts snow, thereby reducing temperature and available oxygen in subnivean spaces and restricting subnivean rodents from those areas or lowering their survival (Neumann and Merriam 1972, pp. 210–211; Schmid 1972, p. 37; CBD 2011, pp. 23–24).
- Snowmobile trails may allow coyotes easier access into areas that would otherwise be difficult to access due to deep snow (Rich 2014a, p. 1).

Although noise from snowmobile operation at dusk might tend to interfere with SNRF hunting in nearby areas, operation at such times is rare (Rich 2014a, p. 1). Snowmobile use is allowed in the Bridgeport Winter Recreation Area (BWRA), in a corridor along highway 108, and in fairly large “semi-primitive” areas to the northwest of the BWRA (see Map 4). These areas receive about 15 snowmobiles per weekday, and 35 per day on weekends and holidays (Boatner 2017, p. 1). Other areas are restricted from snowmobile use, but lack of compliance with those restrictions does occur (Rich 2014a, p. 1).

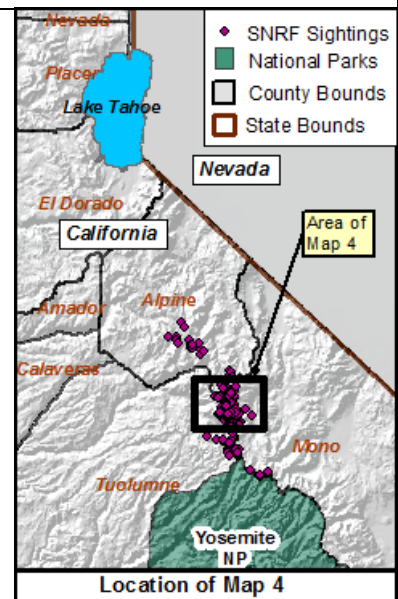




**Map 4:** Areas in the Sonora Pass SNRF Population Area Open to Snowmobile Use (from Rich 2014b, p. 47). BDRA is large white area near center.

The current condition for rodent prey across the general landscape appears to be fairly good. Increased coyote presence, particularly during droughts, may restrict SNRF home ranges to certain areas, and snowmobiles may have some impact on subnivean rodents in the mapped areas, but the extent of such increased current impacts as a proportion of the landscape appears to be relatively low.

**Leporid Prey:** White-tailed jackrabbits and snowshoe hares have been characterized as relatively common and present all year in the Sonora Pass area in recent years (Rich 2014a, p. 1). They may be the primary food source of SNRF in the area (*Id.*), and may represent a food source for which SNRF can outcompete coyotes during winter and early spring, due to the superior ability of SNRF to run over snow (Sacks *et al.* 2017, p. 1). SNRF raise their pups during early spring (see **Reproduction and Life History**, above), so the presence of leporid prey may increase reproductive success by allowing greater survivorship of young.



Although the range of both these leporid species extends the length of the Sierras (CDFW 1995, p. 1; CDFW 2008, p. 1), their distributions, population numbers, and trends are not well known (Quinn 2017, p. 7). They are both considered species of special concern by CDFW (CDFW 2017, p. 51), a designation meaning they are potentially vulnerable to extirpation in California (*Id.* at 10). Snowshoe hare numbers in the Sierras are unknown, but potentially low (CDFW undated, p. 2). White-tailed jackrabbit numbers appear to be declining, both across their entire range (Simes *et al.* 2015. p. 506) and in California (CDFW undated, p. 1); causes for the decline remain unclear (Simes *et al.* 2015. p. 506). Additionally, population numbers of snowshoe hare in northern portions of their range tend to cycle through periods of relative abundance and scarcity, over time periods lasting from 7 to 17 years (USDA undated, p. 5). The extent to which this occurs in California is unclear (Quinn 2017, p. 7), but such cycling may have contributed to a general lack of snowshoe hares in the Lassen Peak area during the early 2000s (Perrine 2005, p. 29), as compared to their presence in the same area in 2017 (Sacks *et al.* 2017, p. 1). White-tailed jackrabbits have also historically exhibited periodic population peaks and troughs (Simes *et al.* 2015, pp. 493, 505), but this also appears to be based on studies outside of California (*Id.* at 493). Snowshoe hares prefer areas with dense cover (CDFW undated, p. 1), whereas white-tailed jackrabbits use more open habitat areas with scattered shrubs (CDFW undated, p. 1). Such open areas are more common in subalpine habitat, such as SNRF typically occupy (Quinn 2017, p. 7).

Accordingly, the current condition for leporids appears to be good (relatively common and present all year) in the Sonora Pass area, but with relatively small or declining populations through the Sierras as a whole.

Whitebark Pine: Whitebark pine is currently undergoing a rangewide decline, and we determined on July 19, 2011, that listing as an endangered or threatened species under the ESA is warranted (76 FR 42631). The most serious threat facing it is an infectious fungus called white pine blister rust (*Cronartium ribicola*) (76 FR 42639). Whitebark pine in California remains less affected by blister rust than most other areas (76 FR 42640–42641), but infection percentages still average about 12 percent and can be as high as 71 percent (*Id.*).

Attacks by mountain pine beetles (*Dendroctonus ponderosae*) were also considered an ongoing serious threat until recently (*Id.* at 42642), but these attacks are currently subsiding (81 FR 87263, Dec 2, 2016). Other threats include wildfires, as affected by past and ongoing fire suppression practices, and changing climate conditions (*Id.*).

Accordingly, the current condition of whitebark pine in the Sierras is somewhat reduced from historical levels, but still likely to serve as an important food source for the Sierra SNRF during those years that whitebark pinenut food caches are available.

Summary of Current Stressors – Habitat Characteristics Affecting Viability

Characteristic	Potential Stressor
Subalpine habitat (Low productivity; Cold)	Changes in climate conditions

Deep winter snow	Drought (affected by changes in climate conditions)
Whitebark pine	Rust disease Mountain pine beetles Fire
Leporids	Low snowpack (affected by changes in climate conditions) Potential unknown stressor causing population decline
Rodents	Coyote competition & exclusion (affected by changes in climate conditions)
	Snowmobile snow compaction

#### 4.2 Current Condition of Demographic Characteristics Affecting Viability

**Population Size:** As discussed under “**Current Range,**” above, Sierra SNRF currently have a single known population, with a total estimated size of about 10 to 50 adults, including about 14 breeding and 15 non-breeding individuals (Sacks 2015, p. 1; Sacks *et al.* 2015, p. 14). This does not account for hybrids, which in 2014 comprised 8 of 10 non-immigrant individuals sighted (Sacks *et al.* 2015, pp. 17, 29). No evidence of reproduction of pure Sierra SNRF was observed at a 130 km<sup>2</sup> (50 mi<sup>2</sup>) study site for the 2011 to 2014 breeding seasons (Sacks *et al.* 2015, pp. 3, 15, 30). This is consistent with low reproductive success stemming from inbreeding depression (*Id.* at 15).

The current condition of the Sierra SNRF population thus includes likely inbreeding depression and a population size much lower than the 150 or more adults estimated (above) as necessary to reduce risks associated with catastrophic events.

**Number of Populations:** As discussed above, a larger population or more populations spread out across the landscape would provide the necessary resiliency or redundancy to spread risk and prevent the potential loss of the DPS from catastrophic events. Currently only one, small population is known. From 1996 to 2002, carnivore surveys using track plates and baited camera stations were conducted across most of the SNRF’s California range, both by National Forest biologists (Perrine *et al.* 2010, pp. 8, 11), and by members of the USDA’s Pacific Southwest Research Station (Zielinski *et al.* 2005, entire). The National Park Service also conducted similar surveys in Kings Canyon, Sequoia, and Yosemite National Parks (Perrine *et al.* 2010, pp. 8–9). Some of these surveys emphasized lower elevation forests, however, or methods more likely to detect arboreal predators such as fishers and martens; thus additional surveys designed specifically for Sierra SNRF would be useful (Sacks 2017, p. 4).

Based on existing data, Sierra SNRF appear restricted to a single population. Their current condition with regard to this demographic characteristic therefore appears poor.

**Distribution of Populations Across Range:** Map 3, above, shows the general locations of potentially suitable habitat that could provide for a larger or multiple populations of Sierra SNRF. Populating a larger area or multiple areas within the species historical range would

increase the DPS’s ability to adapt to changing environmental conditions over time. Currently, the only existing population occupies part of the middle portion of the DPS’s historical range (see Map 2, above), and presumably has characteristics adapted to that area. By expanding this population area or reestablishing additional populations across the range, the DPS as a whole would be exposed to a wider variety of local conditions, and eventually evolve a wider variety of adaptations and local genetic distinctions. That genetic variability in turn provides greater flexibility to address potential future environmental changes. The current condition of this demographic characteristic is poor given its current distribution.

Native Genomic Integrity: Prior to the spring of 2013, no reproduction between native SNRF and nonnative immigrant foxes had occurred (Sacks *et al.* 2015, p. 9; Sacks 2017, p. 4). However, two nonnative male red foxes with a mixture of montane (*V. v. macroura*) and fur-farm ancestry arrived at the Sonora Pass study area in 2012, and by 2014 had produced a total of 11 hybrid pups (*Id.* at 3, 10, 29–30). As discussed above, these constituted the only known pups produced in the study area during the four breeding seasons from 2011 to 2014 (*Id.* at 3, 15, 30). A third nonnative male was sighted (once) in 2014, bringing the known population in that year to three nonnatives, eight hybrids, and only two native SNRF (*Id.* at 17, 22, 29).

Available evidence thus suggests that the current condition with regard to maintaining high genomic integrity is poor, depending on the extent to which hybridization may be happening in portions of the population outside of the current study area. That area included 20 to 50 percent of available contiguous high quality habitat (Sacks *et al.* 2015, p. 14). However, see the discussion of future Native Genomic Integrity under Section 5.2, below.

Summary of Current Stressors – Demographic Characteristics Affecting Viability

Characteristic	Potential Stressor
≥ 150 native adults per population	Inbreeding depression
	Hybridization
Larger population or multiple populations in other portions of the DPS’s range	Low population size
	Low rate of increase
High native genomic integrity	Low native reproduction
	High hybrid production
Sierra SNRF presence in additional areas of historical range with varied local characteristics	Low population size
	Low rate of increase

**4.3 Current Condition of Demographic Characteristics Affecting Viability**

Although the CDFW (2015, p. 2) has noted cases of rabies and distemper in gray foxes in Lassen County, to our knowledge none of the pictures available from camera traps, or direct examinations of foxes captured for radio tagging, have indicated disease in SNRF anywhere in California. Perrine (2005, p. 154) noted that “we have no data on the impact of rabies, canine distemper, or other diseases upon mountain red fox in North America.”

Summary of Current Conditions: With regard to environmental characteristics affecting viability, the condition of the DPS is somewhat worse than what it was historically, but still generally good. For demographic characteristics affecting viability, the DPS is generally in poor condition (see Table 1, Section 6.0, below). Disease does not currently appear to be affecting viability.

## 5.0 Future Conditions

In this section we address the extent to which environmental or demographic characteristics may affect the viability of the Sierra SNRF in the future (within 50 years).

For our future conditions analysis, we considered the best available information on potential stressors to determine the most likely future trends of the DPS and its habitat conditions. Those stressors that were found to be insignificant currently (i.e., negligible or individual-level impacts as opposed to DPS-wide impacts) and not likely to increase in magnitude to a DPS-wide impact in the future were not carried forward into the future condition analysis. We evaluated the remaining stressors under the following scenarios of possible future conditions:

(1) **Increased Viability Scenario** (Current conditions improve in the future):

- Climate cools, increasing total area of subalpine habitat.
- Average winter and spring snowpack levels increase, discouraging coyote migration into subalpine areas and providing SNRF with better chances of outcompeting coyotes for leporids.
- Rodent prey levels increase or stay the same, while access to hunting areas is increased due to lessened coyote competition.
- Leporids are generally common, and competition with coyotes for them is reduced due to fewer coyotes, increased snowpacks, or both.
- Whitebark pine seed availability increases.
- Existing Sierra SNRF population increases to about 150 or beyond.
- New Sierra SNRF populations become established, or the area of the existing population significantly increases, such that a majority of habitat variation across the historical range is included within the existing range.
- Nonnative alleles resulting from hybridization become less common in the population.

(2) **Status Quo Scenario** (Current conditions persist into the future):

- Temperatures and coyote numbers remain roughly the same. Sierra SNRF remain in their current general range near Sonora Pass.
- Average winter and spring snowpacks remain largely unchanged. Coyote incursion stays at current levels.
- The availability of rodent prey to Sierra SNRF remains at current levels.
- Access to leporid prey populations remains at current levels.
- Availability of whitebark pine seeds remains at current levels.

- The population of native Sierra SNRF remains significantly below 150, and thus vulnerable to extirpation by deleterious chance events.
- A single Sierra SNRF population remains in the center of the historical range.
- Nonnative alleles resulting from hybridization remain common in the population, but do not replace the adaptive native alleles.

**(3) Decreased Viability Scenario** (Current conditions worsen in the future):

- Habitat warms such that coyotes are no longer uncommon.
- Winter and spring snowpacks decrease such that coyotes are relatively common in most areas of the range and are able to compete successfully with SNRF for leporid prey.
- Rodent prey available to SNRF significantly decreases, due either to reduced rodent populations, competition from coyotes, or exclusion of SNRF from hunting areas by coyotes.
- Access to leporid prey becomes difficult due to low snowpack or low leporid population numbers.
- Whitebark pine nut caches become increasingly scarce.
- Population of native SNRF declines below current numbers, either in response to deleterious chance events, or as part of a longer-term decline resulting from inbreeding depression or other stressors.
- A single, small, Sierra SNRF population remains in the center of the range, and that population exhibits decreased resiliency, either in response to chance events or to other stressors.
- Current levels of hybridization increase significantly and tend to swamp out and replace adaptive native alleles.

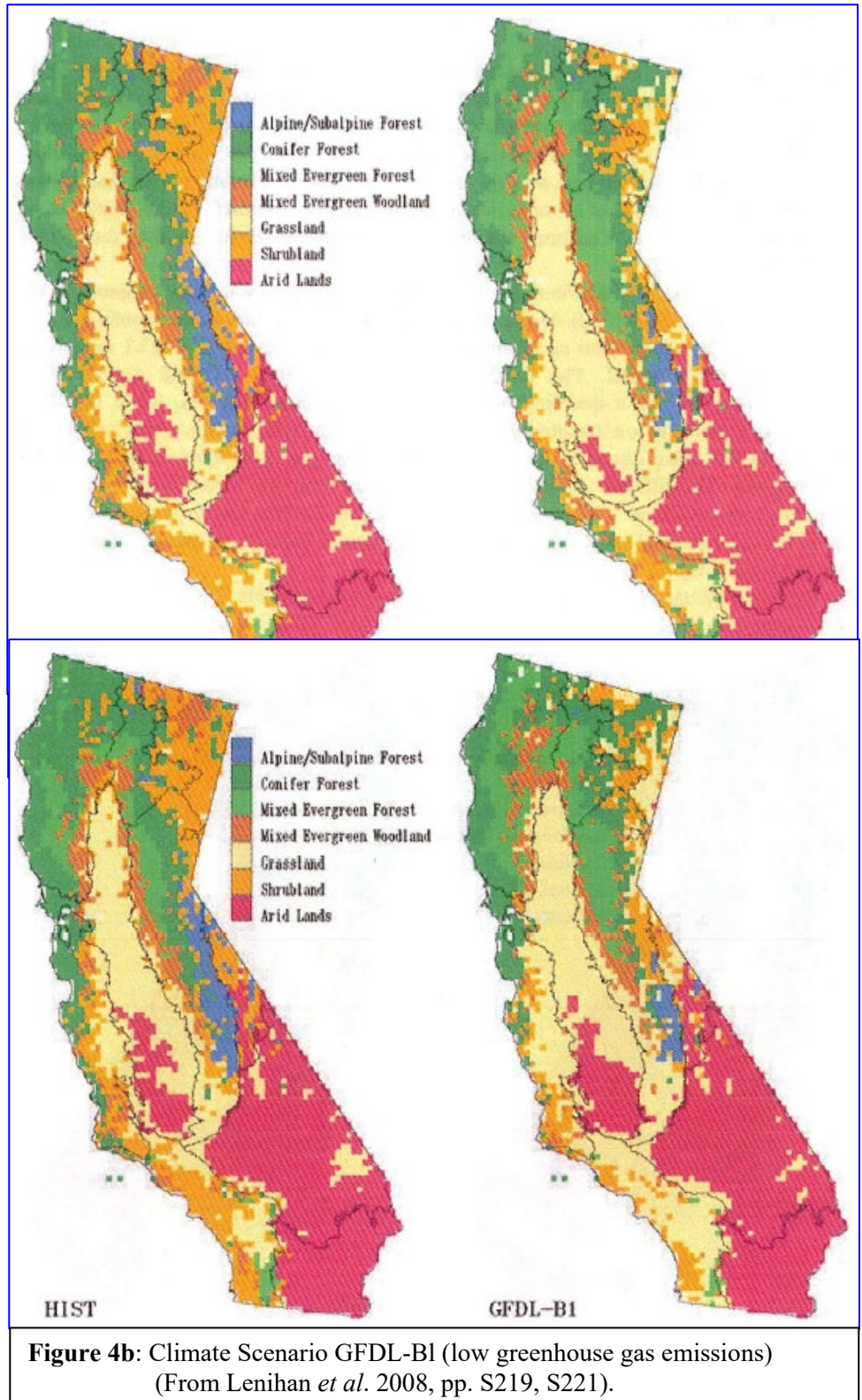
Under each of the stressors in the future condition analysis we identify which scenario is most likely and why based on the best available information at this time. We indicate our confidence of this assessment of future trend based on the degree of uncertainty an action or event will occur, and if it occurs, the level of habitat or population change that may result.

## 5.1 Future Condition of Environmental Characteristics Affecting Viability

### Subalpine habitat primary productivity and coyote presence:

Lenihan *et al.* (2008, pp. S219–S222) mapped historical and future vegetation data for California as modeled under three future climate scenarios. Results are provided to the right, and below, in order of most optimistic to pessimistic climate scenario, with future conditions (2017 – 2099) on the right.

In all three scenarios, “alpine/subalpine forest” retreats to south of the Sonora Pass area. We therefore expect that the current population location will likely change from subalpine habitat, although this change may not be quite complete within 50 years. The habitat change likely reflects changes in temperature and primary productivity that may encourage more coyotes to enter SNRF habitat, particularly in the Sonora Pass area. SNRF, which are adapted to subalpine habitat, may be forced into the little remaining alpine habitat to the south. The Decreased Viability scenario for SNRF is thus the most likely result for this stressor.

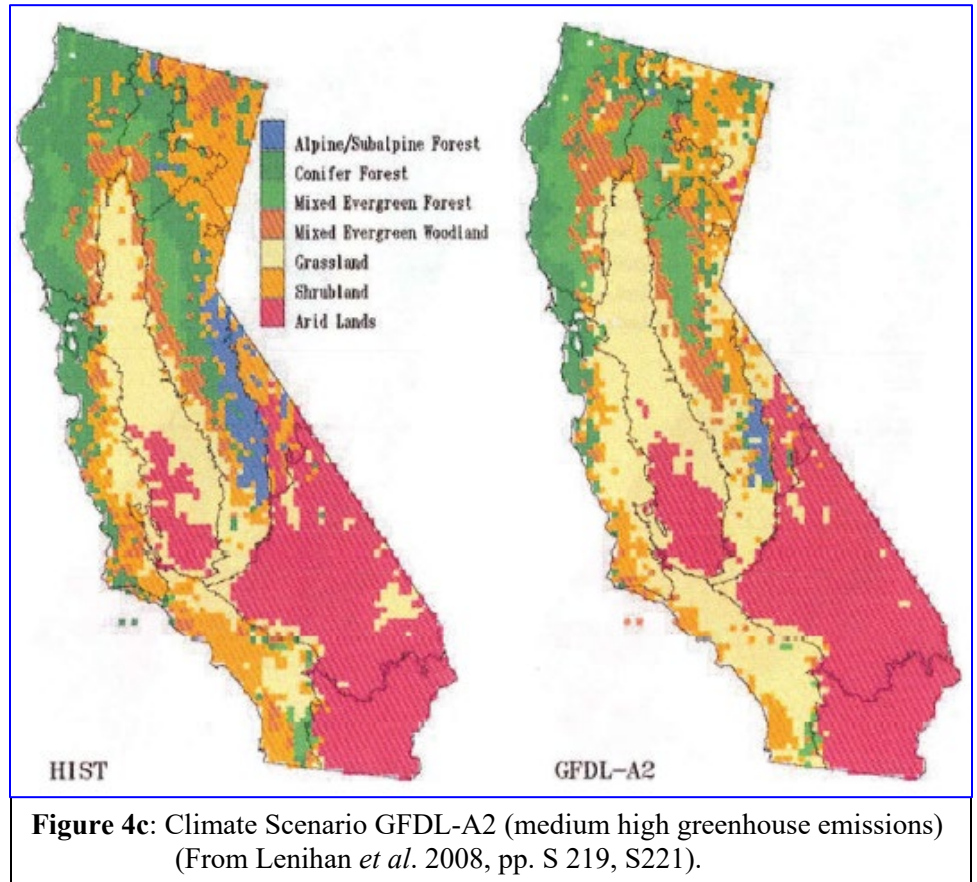


**Figure 4b:** Climate Scenario GFDL-B1 (low greenhouse gas emissions)  
(From Lenihan *et al.* 2008, pp. S219, S221).

### Deep Winter and Spring Snowpacks:

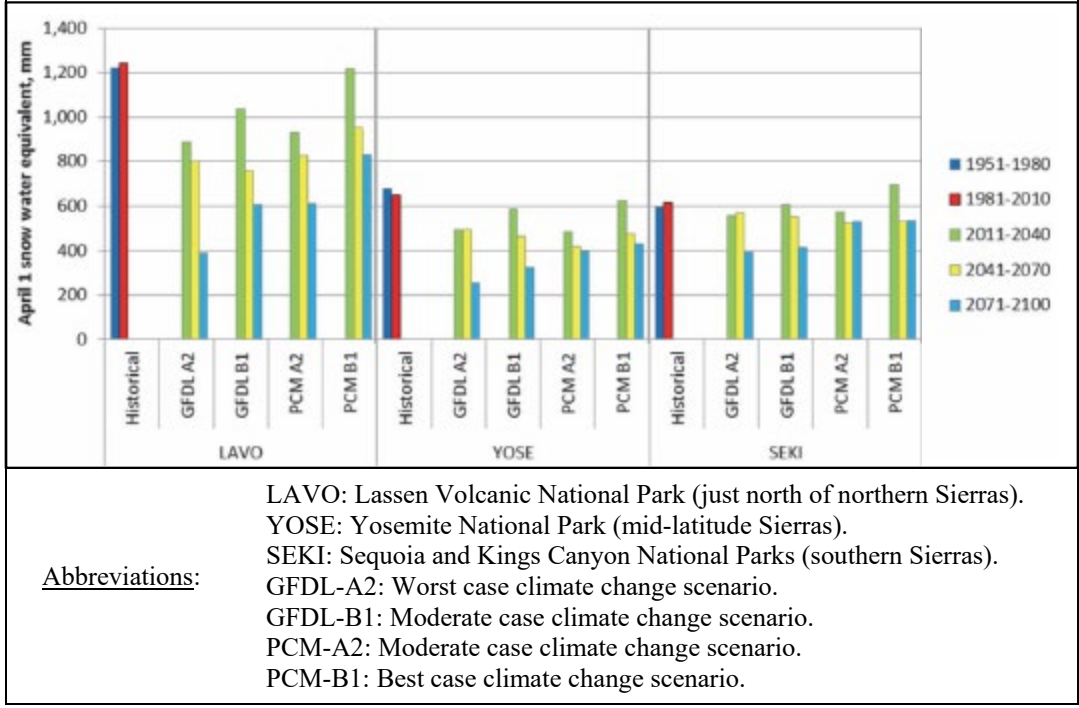
Curtis *et al.* (2014, entire) considered the effects of cold air pooling on projected future snowpack levels in the Sierras. Cold air pooling is a process by which calm air near the ground cools overnight and then collects in topographic depressions (*Id.* at 1). They found that cold air pooling, averaged over the landscape of the Sierras and Cascades allowed a correction factor of  $-1.6^{\circ}\text{C}$  ( $3^{\circ}\text{F}$ ) to be applied to climate change models for applicable areas (*Id.* at 4–5). They then modeled future snowpack under various climate change scenarios using this correction factor.

Their results, as applied to three national parks in or near the northern, central, and southern Sierras, are shown in Figure 5, below. SWEs are typically highest near April 1<sup>st</sup> (Kapnick and Hall 2010, p. 2447). An SWE of 400 mm, (15.75 in) is roughly equivalent to a snow depth of about 1 m (3.3 ft) (Curtis *et al.* 2014, pp. 4, 10).





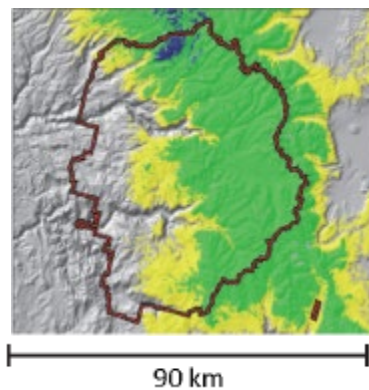
**Figure 5:** Projected snowpack water capacities after accounting for cold air pooling.  
(From Curtis *et al.* 2014, p. 9).



The snowpack projections in Figure 5 show that under all four climate change scenarios, snowpacks are likely to be lower in the Yosemite area (the general location of the DPS’s current population) in 50 years than anywhere else in the range (compare yellow bars). These average snowpack levels, will range from 400 to 500 mm SWE (15.75 to 20 in as compared to 23.6 in), depending on the warming scenario. Although the blue bars apply to a time period that begins just beyond our established 50-year period of future consideration, they are still informative because they indicate what the trend is likely to be towards the end of that period.

Decreases in average snowpack levels will result in decreases in the extent of high snowpacks as well. Figures 6a and 6b, below, provide a general sense of the decreases to be expected starting in 2071 (slightly more than 50 years) using a moderate and a worst case climate change scenario. Decreases within 50 years would presumably be slightly less.

In 50 years, the general area of the current SNRF population is thus likely to undergo a moderate to severe loss in the extent of area with

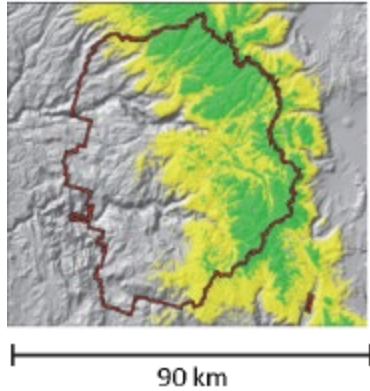


**Figure 6a:** Future Yosemite Snowpack Levels (2071–2100)  
 Climate Scenario: PCM-A2 (moderate emissions)  
 April 1 SWE, mm

0 - 100	100 - 400
400 - 1,000	1,000 - 1,500

(from Curtis *et al.* 2014, p. 11)

sufficiently high snowpack to minimize coyote presence. This loss may increase severely beginning slightly after 50 years from now under the worst-case scenario.

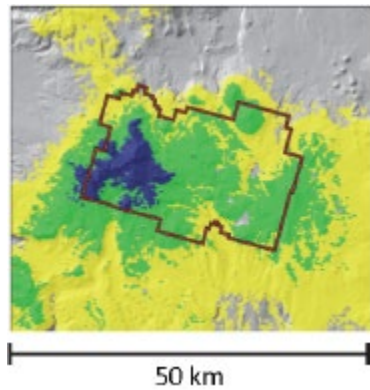


**Figure 6b:** Future Yosemite Snowpack Levels (2071–2100)  
 Climate Scenario: GFDL-A2 (med-high emissions)  
 April 1 SWE, mm

0 - 100	100 - 400
400 - 1,000	1,000 - 1,500

(from Curtis *et al.* 2014, p. 11)

*Northern Sierras:* In the northern Sierras, average snowpacks are likely to stay higher than everywhere else in the range, under all climate scenarios, for the next 50 years (Figure 5, LAVO, green and yellow bars). This is based on projected snowpacks at Lassen Volcanic National Park (LAVO), which is slightly north of the northern Sierras. Average elevations at LAVO (about 2,100 m (6,890 ft)) are actually lower than in



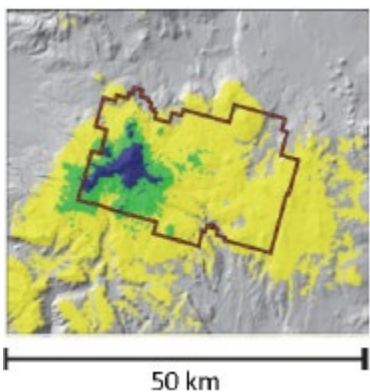
**Figure 6c:** Future Lassen Nat'l Park Snowpack Levels (2071–2100)  
 Climate Scenario: PCM-A2 (moderate emissions)  
 April 1 SWE, mm

0 - 100	100 - 400
400 - 1,000	1,000 - 1,500

(from Curtis *et al.* 2014, p. 11)

Yosemite (about 2,400 m (7,874 ft)), or in Sequoia and Kings Canyon (about 2,800 m (9,186 ft)).

In slightly more than 50 years, however, average snowpacks are projected to drop to 600 mm SWE (23.6 in) under the two



**Figure 6d:** Future Lassen Nat'l Park Snowpack Levels (2071–2100)  
 Climate Scenario: GFDL-A2 (med-high emissions)  
 April 1 SWE, mm

0 - 100	100 - 400
400 - 1,000	1,000 - 1,500

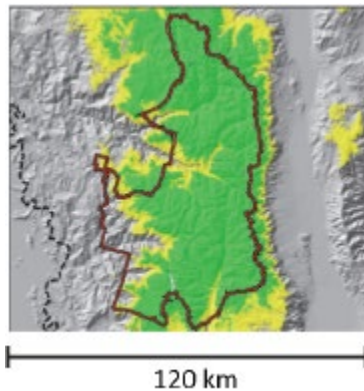
(from Curtis *et al.* 2014, p. 11)

moderate case scenarios, and to 400 mm SWE (15.75 in) (about 1 m) in the worst case scenario (Figure 5, LAVO, blue bars). Presumably they would be in the process of dropping towards the end of the 50 year period. The two moderate case scenarios would thus still leave similar snowpack levels to what currently exist at Yosemite, and the best case scenario would leave considerably more than that (800 mm SWE (31.5 in)).

Habitat with sufficiently high snowpacks to minimize coyote presence will thus continue to exist in the northern Sierras to a greater extent than elsewhere in the range. Climate change is still likely to lead to losses in the extent of such habitat, however, as shown graphically in Figures 6c and 6d below.

*Southern Sierras:* In the southern Sierras, average snowpacks are projected to remain roughly the same for the next 50 years under all climate change scenarios (Figure 5, SEKI, green and yellow bars). Under the best case scenario, snowpacks actually increase until 2040 before dropping to somewhat below current levels thereafter. Slightly after the next 50 years, snowpack levels drop to about 400 mm SWE (15.75 in) in the worst case scenario and one of the moderate scenarios, while remaining relatively close to 600 mm SWE (23.6 in) in the other two scenarios (Figure 5, SEKI, blue bars).

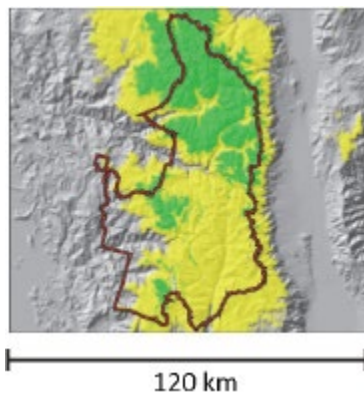
Losses in the area of habitat with sufficient snowpack in the southern Sierras can be inferred somewhat from the graphical differences shown in Figures 6e and 6f, below.



**Figure 6e:** Future Sequoia / Kings Canyon Snowpack Levels (2071–2100)  
Climate Scenario: PCM-A2 (moderate emissions)  
April 1 SWE, mm

0 - 100	100 - 400
400 - 1,000	1,000 - 1,500

(from Curtis *et al.* 2014, p. 11)



**Figure 6f:** Future Sequoia / Kings Canyon Snowpack Levels (2071–2100)  
Climate Scenario: GFDL-A2 (med-high emissions)  
April 1 SWE, mm

0 - 100	100 - 400
400 - 1,000	1,000 - 1,500

(from Curtis *et al.* 2014, p. 11)

*Summary:* Based on these projections, in 50 years we expect average snowpacks in the central Sierras (the current location of the only known Sierra SNRF population) will likely be lowest, regardless of climate change scenario, followed by the southern Sierras and then the northern Sierras. This likely means loss of habitat with snowpacks sufficiently high to exclude most coyotes. The actual extent of such loss is unclear, but based on comparisons of current snowpack levels (Figures 3a through 3c) with projected snowpack levels (Figures 6a through 6f), losses will likely be considerable to extensive under moderate to severe climate change

scenarios. Projections for the period beginning in slightly more than 50 years show more snowpack loss in all areas under all but the best case climate change scenario. This should be considered even for 50-year projections because snowpacks may begin dropping towards the new levels prior to the end of the 50-year period. The lowest projected average snowpack levels (about 250 mm SWE (9.8 in)) are in the mid Sierras under the worst case climate scenario, slightly after 50 years.

Overall, habitat with sufficient snowpack is likely to decrease significantly, but not completely. This may result in a situation about halfway between the “Status Quo” and “Decreased Viability” scenarios, most likely after 50 years.

Rodent Prey: Because rodents currently occupy a wide range of habitats and climatic conditions, and because SNRF are generalist predators and capable of taking whatever rodent species happen to be present in their area, we do not expect climate change to cause direct significant impacts to the availability of rodent prey species. Climate change may tend to increase coyote competition, as addressed above. It may also tend to decrease total snowmobile use over the course of a season, which may lessen potential impacts on subnivean rodent prey. Accordingly, we expect the status quo scenario for SNRF to apply with respect to this potential stressor.

Leporid Prey: Leporids are important to SNRF because they are relatively large prey available in the winter and during the fox’s reproductive months (Quinn 2017, p. 7; Sacks 2017, p. 3; Sacks *et al.* 2015, p. 15). In the presence of relatively high snowpacks, SNRF are presumably better able to compete with coyotes for this prey item as compared to other prey. Because white-tailed jackrabbits are in decline, and because snowshoe hare and white-tailed jackrabbit populations in California may tend to cycle through periods of abundance and scarcity as they do in other areas (USFS undated, p. 5, Simes *et al.* 2015, pp. 493, 505), these are not likely to remain a consistent food source even in areas where snowpacks remain high. Accordingly, the Decreased Viability scenario is more likely overall, although there will be times and places during which the status quo scenario applies.

Whitebark Pine: The threats currently facing whitebark pine (white pine blister rust and mountain pine beetles, as exacerbated by climate change effects) are likely to greatly reduce whitebark pine populations over the next 50 years, assuming no breakthrough conservation solutions are developed such as an easily-applied inoculant against blister rust. Therefore, the Decreased Viability scenario is most likely with regard to stressors on this habitat characteristic.

Summary of Future Stressors – Habitat Characteristics Affecting Viability

<b>Characteristic</b>	<b>Potential Stressor</b>
Subalpine habitat (Low productivity; Cold)	Changes in climate conditions
Deep winter snow	Changes in climate conditions
	Drought (affected by climate change).
Whitebark pine	White pine blister rust
	Mountain pine beetles (affected by changes in climate conditions)
	Changes in climate conditions
Leporids	Low snowpack (affected by changes in climate conditions)

	Declining or variable population
Rodents	Increased coyote competition (affected by changes in climate conditions)
	Increased snowmobile snow compaction

## 5.2 Future Condition of Demographic Characteristics Affecting Viability

Native Genomic Integrity: A study of the Sonora Pass population covering 130 km<sup>2</sup> (50 mi<sup>2</sup>) and 5 breeding seasons, documented the production of 18 hybrids and 0 native Sierra SNRF pups (Quinn and Sacks 2016, p. 2). The observed high production of hybrids, coupled with a lack of reproduction between purely native individuals, is consistent with inbreeding depression in pure SNRF (Sacks *et al.* 2015, p. 14; Quinn and Sacks 2016, p. 2). The population thus currently includes a mix of native (SNRF) and nonnative (non-SNRF) alleles, and those nonnative alleles are likely to spread throughout population in the future.

The introduction of non-native alleles will tend to reduce the proportion of native alleles remaining in the population, at least to some extent (Sacks 2017, p. 7). However, the nonnative alleles will also tend to dilute deleterious recessive alleles previously fixed in the native population, thereby tending to alleviate inbreeding depression and enabling the population as a whole to increase in abundance (*Id.*). If this causes the population size to increase, then the overall numbers of both native and nonnative genes should also increase. Natural selection, acting on a larger and more stable population, will tend to out individuals lacking adaptive native alleles, thereby reestablishing high proportions of those native genes uniquely important to the survival of the DPS in its native habitat (*Id.*). The current influx of nonnative alleles into the population may thus serve to rescue the population from inbreeding depression, but the outcome will depend on how rapidly and to what extent the population grows (*Id.*). Other forces, such as continued interbreeding with nonnative populations, genetic drift, or even interbreeding with individuals from as-yet-undiscovered native SNRF populations, will also affect this scenario (*Id.*).

Under worst-case conditions, new nonnative individuals and their alleles would be continually introduced to the population, leading to genetic swamping and loss of the native genome (Sacks *et al.* 2015, p. 17). Even if no new nonnative individuals are introduced, if the population fails to grow large enough later generations could be subjected to a return to inbreeding depression, potentially exacerbated by the new deleterious alleles introduced by the nonnative individuals (Sacks *et al.* 2015, pp. 16, 17). Outbreeding depression is also a concern, particularly if native locally adapted alleles are replaced or if their complexes are broken up by the introduction of nonnative alleles (*Id.* at 17). The best case scenario, and therefore most proactive consideration, is that the population, now provisionally released from the effects of inbreeding depression, increases and expands carrying with it the locally adapted native alleles. Once a population achieves larger size, then selection would become an important force favoring retention of those alleles that define a SNRF phenotype. As an initial response to the outbreeding, the population appears to have been increasing and expanding over the past several years and native genes are carried by most of them (Sacks 2017, p. 8). A visible example of this is coat-color. The nonnative males were red, yet the now larger population contains multiple cross and black fur pattern foxes, representing native genes and phenotypes. Thus, although multiple outcomes are

possible, in the absence of monitoring and management, we consider the Decreased Viability Scenario more likely over the next 50 years for this characteristic.

Population Size: Given that the current size of the population is estimated at 10 to 50 adults (roughly half of which are assumed to be non-breeding), the population growth rate would have to be approximately 5 percent per year in order to reach a minimum viable size of approximately 150 adults within 50 years (see Demographic Characteristics Affecting Viability, above). The Sierra SNRF population now incorporates nonnative genes, which appear to have alleviated inbreeding depression and allowed increased production of pups, at least for the time being (Quinn and Sacks 2016, p. 2). However, Sierra SNRF population numbers began falling in the mid-1900s (Schempf and White 1977, p. 44), and it is unlikely that an influx of nonnative genes alone will reverse that trend so completely as to allow 5 percent growth over the next 50 years. Continued population growth may also be threatened by deleterious chance events such as drought or diseases, and it will likely be curtailed or suffer setbacks due to habitat changes such as increased coyote presence, and leporid or whitebark pine losses, as discussed under Section 5.1, above. Failure of the population to increase sufficiently could cause a return of inbreeding depression, as discussed under Native Genomic Integrity, above. Any of these negative impacts could (and likely will) occur over the next 50 years, particularly in the absence of monitoring and management. Accordingly, the population is most likely to follow the Status Quo Scenario, leaving the overall DPS in a precarious state of viability with regard to population numbers.

Number and Distribution of Populations Across the Range: Only one, small population of Sierra SNRF is currently known (see Demographic Characteristics Affecting Viability, above), so any new populations would presumably need to be colonized by individuals dispersing from that existing population near Sonora Pass. That would be most likely if the growth rate of native Sierra SNRF numbers in that population were relatively high over the next 50 years, and if large portions of the range continue to support habitat characteristics beneficial to Sierra SNRF. As discussed under above under Population Size and in section 5.2, neither of those things appear likely. However, recent interbreeding with nonnatives appears to have increased the number of young produced and alleviated inbreeding depression (see Population Size, above). So while the viability of the single existing population remains precarious, it does not appear to be decreasing. Accordingly, we consider the Status Quo Scenario more likely for number and distribution of population(s).

Summary of Future Stressors – Demographic Characteristics Affecting Viability

<b>Characteristic</b>	<b>Potential Future Stressor</b>
≥ 150 native adults per population	<ul style="list-style-type: none"> <li>• Requires unusually high population growth</li> <li>• Chance deleterious events</li> </ul>
Larger population or multiple populations	<ul style="list-style-type: none"> <li>• Requires unusually high population growth</li> <li>• Chance deleterious events</li> </ul>
High native genomic integrity	<ul style="list-style-type: none"> <li>• Potential gene swamping</li> </ul>
Sierra SNRF presence in additional areas of historical range with varied local characteristics	<ul style="list-style-type: none"> <li>• Requires unusually high population growth</li> <li>• Chance deleterious events</li> </ul>

### **5.3 Future Condition of Disease and Potential Effects on Viability**

Future disease impacts on the Sierra SNRF are difficult to predict, but the historically low population densities of SNRF (Perrine *et al.* 2010, p. 9) should make a potential future transmission within a population less likely except within family groups. The relative isolation of the Sierra SNRF population near Sonora Pass from the nearest Cascades SNRF population near Lassen Peak should also make a potential future transmission across DPSs unlikely. However, relatively small disease outbreaks remain possible as “deleterious chance events,” as discussed above under Section 3.2, **Population Size**.

### **5.4 Future Conservation Measures**

A Sierra Nevada red fox working group has been formed by representatives of several Federal and State environmental agencies, state universities, and nongovernmental conservation organizations (SNRFGWG 2015, p. 1; SNRFGWG 2016, p. 1). In addition to continued monitoring of the Sierra SNRF, the working group proposed to develop a conservation strategy, which in turn would include a genetic management plan and a feasibility assessment for conducting translocations of SNRF across populations, such as from the Cascades SNRF population at Lassen to the Sierra SNRF population at Sonora Pass (SNRFGWG 2016, pp. 2–6). The point of managed SNRF translocations would be to help reduce the likelihood of a return to inbreeding depression and to counter introgression of nonnative alleles by introducing, in a controlled and monitored manner, new alleles into the Sierra SNRF population that are more likely to code for native local adaptations (*Id.* at 3). So far, these ideas have not been significantly advanced, but if they were to be carried out carefully in the near future, they could potentially address the primary stressors (hybridization and inbreeding depression) on native population size and genomic integrity at the Sonora Pass population. By removing impediments to native population growth at that location, they would also increase the probability of later dispersal of young adults to new locations, where they might found new populations or increase the range of the existing population. These measures could thus potentially address all the demographic characteristics affecting viability, thereby increasing the long-term viability of the DPS considerably.

## **6.0 Existing Regulatory Mechanisms**

Existing regulatory mechanisms that affect the Sierra SNRF include laws and regulations of the Federal government and of the State of California. Such laws and regulations address issues that might otherwise affect Sierra SNRF viability, such as hunting, fuels management, and project planning on Federal lands.

### Federal Regulations

There are a number of Federal agency regulations that pertain to management of Sierra SNRF or its habitat. Most Federal activities must comply with the National Environmental Policy Act of 1969, as amended (NEPA) (42 U.S.C. §§ 4321 *et seq.*). NEPA requires Federal agencies to formally document, consider, and publicly disclose the environmental impacts of major Federal actions and management decisions significantly affecting the human environment. NEPA does

not regulate or protect Sierra SNRF, but requires full evaluation and disclosure of the effects of Federal actions on the environment. NEPA does not require or guide potential mitigation for impacts.

#### *U.S. Forest Service (USFS)*

The USFS policy manual (USFS 2005, section 2670.22) allows for designation of sensitive species of management concern. The Sierra SNRF has been identified as a sensitive species where it occurs on National Forests in California (U.S. Forest Service Regions 4 and 5) since 1998. The Sensitive Species Policy is contained in the USFS Manual, section 2670.32 (USFS 2005, section 2670.32) and calls for National Forests to assist and coordinate with other Federal agencies and States to conserve these species. Special consideration for the species is made during land use planning and activity implementation to ensure species viability and to preclude population declines that could lead to a Federal listing under the ESA (USFS 2005, section 2670.22). Proposed programs and activities must be analyzed for their potential effect on sensitive species. For example and at this time, proposed activities that occur within the applicable national forests will include measures to avoid or minimize project-related impacts to Sierra SNRF and its habitat. If species viability is a concern, impacts are avoided or minimized; if impacts cannot be avoided, a further analysis of the significance of potential adverse effects is required; the action must not result in loss of species viability or create significant trends toward Federal listing (USFS 2005, section 2670.32).

National Forest management is directed by the Multiple-Use Sustained-Yield Act of 1960, as amended (16 U.S.C. §§ 528 *et seq.*) and the National Forest Management Act of 1976, as amended (NFMA) (90 Stat. 2949 *et seq.*; 16 U.S.C. §§ 1601 *et seq.*). NFMA specifies that the Forest Service must have a land and resource management plan (LRMP) to guide and set standards for all natural resource management activities on each National Forest or National Grassland. Current LRMPs were developed under the 1982 planning rule (47 FR 43026, September 30, 1982, pp. 43037–43052), which required the Forest Service to maintain viable populations of existing native and desired nonnative vertebrate species.

The USFS has recently revised their NFMA planning rules (77 FR 21162, April 9, 2012), which will apply to future LRMP revisions. The revised NFMA planning rules require the Forests to use an ecosystem and species-specific approach in their LRMPs to provide for the diversity of plant and animal communities and maintain the persistence of native species in the plan areas. This includes contributing to the recovery of federally listed endangered and threatened species, conserving proposed and candidate species, and maintaining viable populations of species of conservation concern (77 FR 21162, April 9, 2012, pp. 21169–21272). Directives for implementing the revised rules are not finalized, so it is unclear how this change will affect Sierra SNRFs and their habitat, but the Sierra SNRF will likely become a species of conservation concern under the new policy in all the National Forests in which it occurs (Chatel 2015, p. 1).

*Sierra Nevada Forest Plan Amendment (SNFPA)*: Forest Service lands in California in the Sonora Pass area (Toiyabe and Stanislaus National Forests) operate under LRMPs that have been amended by the SNFPA, which was finalized in 2004 (USFS 2004a, pp. 16, 100, 361–362, 418; USFS 2001, entire; USFS 2004b, entire). The SNFPA requires fire and fuels management



projects in most areas to retain at least 40 percent (preferably 50 percent) canopy cover within a treatment unit, and effectively requires retention of trees 63.5 cm (25 in) diameter-at-breast-height (dbh) in most treated areas (USFS 2004b, pp. 5, 50). This is close to the preferred winter habitat characteristics discussed above for the Lassen Sighting Areas (60 cm (23.6 in) dbh and 40 percent or greater canopy closure). Areas near buildings and other human development (commonly referred to as the wildland urban interface) receive less protection: trees of 76 cm (30 in) dbh or greater are retained, and there are no canopy cover requirements. However, the SNFPA also requires managers to minimize fragmentation of old forest habitat (USFS 2004b, pp. 53–54).

SNFPA Standard and Guideline #32 requires the Forest Service to conduct an analysis to determine whether activities within 8 km (5 mi) of a verified Sierra SNRF sighting have the potential to affect the species (USFS 2004b, p. 54). It also mandates a limited operating period of January 1 to June 30 as necessary to avoid adverse impacts to potential breeding, and it requires 2 years of evaluations for activities near sightings that are not associated with a den site.

*Omnibus Public Land Management Act of 2009 (OPLMA)*: The OPLMA (PL 111-11, p. 1059) establishes the BWRA, consisting of about 2,833 ha (7,000 ac) in the northern portion of the Sonora Pass siting area on Forest Service land (USFS 2010, p. 4). The OPLMA states that the winter use of snowmobiles is allowed in the BWRA, subject to terms and conditions established by the Secretary of Agriculture. Prior to passage of this act, the area had been under consideration for designation as wilderness, although snowmobile use had been allowed in the area since 2005 (USFS 2010, pp. 3–4). The USFS completed a management plan that calls for monitoring of impacts to wildlife (USFS 2010, p. 9), and is proceeding with evaluations of impacts to Sierra SNRF in accordance with SNFPA Standard and Guideline #32 (above).

### *National Park Service*

Statutory direction for the National Park Service lands that overlap the Sierra SNRF's range is provided by provisions of the National Park Service Organic Act of 1916, as amended (16 U.S.C. §§ 1 *et seq.*) and the National Park Service General Authorities Act of 1970 (16 U.S.C. §§ 1a-1). The purpose of national parks, monuments, and reservations is to: “conserve the scenery and the natural and historic objects and the wild life [*sic*] therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations” (16 U.S.C. §§ 1 *et seq.*). More specifically, natural resources are managed to: “preserve fundamental physical and biological processes, as well as individual species, features, and plant and animal communities” (NPS 2006, p. 26). Land management plans for the National Parks do not contain specific measures to protect Sierra SNRFs or their habitat, but areas not developed specifically for recreation and camping are managed toward natural processes and species composition and are expected to maintain Sierra SNRF habitat. Prescribed fire is often used as a habitat management tool by the National Park Service. The effects of these burns on Sierra SNRFs have not been directly studied, but there are no reports of direct mortality to red foxes from fires (Tesky 1995, p. 7), and fuels reduction through prescribed fire will likely benefit Sierra SNRFs in the long term by reducing the threat of Sierra SNRF habitat loss (Truex and Zielinski 2013, p. 90; Zielinski 2014, pp. 411–412). Hunting and trapping are generally prohibited in National Parks (16 U.S.C. § 127). National Park Service

policy allows these activities on their lands if the actions do not unacceptably impact Park resources or natural processes (NPS 2006, pp. 46–47); however, they are not currently allowed in Yosemite National Park. Hunting and trapping is also prohibited in Sequoia and Kings Canyon National Parks (which are not known to contain current populations, but are in the Sierra SNRF’s historical range).

#### *U.S. Department of Defense (DOD)*

*Sikes Act Improvement Act of 1997 (Sikes Act) (16 U.S.C. 670a)*: The Sikes Act required each military installation that includes land and water suitable for the conservation and management of natural resources to complete an integrated natural resource management plan (INRMP) by November 17, 2001. An INRMP integrates implementation of the military mission of the installation with stewardship of the natural resources found on the base. Each INRMP includes: (1) An assessment of the ecological needs on the installation, including the need to provide for the conservation of listed species; (2) a statement of goals and priorities; (3) a detailed description of management actions for implementation to provide for these ecological needs; and (4) a monitoring and adaptive management plan. Among other things, each INRMP must, to the extent appropriate and applicable, provide for fish and wildlife management; fish and wildlife habitat enhancement or modification; wetland protection, enhancement, and restoration where necessary to support fish and wildlife; and enforcement of applicable natural resource laws. We consult with the military on the development and implementation of INRMPs for installations with listed species.

The U.S. Marine Corps’ Mountain Warfare Training Center (MWTC) has lands within the area of the Sierra SNRF population at Sonora Pass. Some MWTC lands were recently acquired, and although the total DOD-owned acreage (approximately 243 ha (600 ac)) is below the Sikes Act criterion, the MWTC has initiated preparation of an INRMP (Norquist 2014, p. 2), and it is now in its final stage of writing (Husung 2017, p. 1). Because the INRMP is not yet finalized, we cannot evaluate its adequacy as an existing regulatory mechanism. The MWTC has set up monitoring cameras to survey for SNRF within their Special Use Area in the winter of 2016/2017, but unusually high snow depth led to loss of cameras and bait stations (*Id.*). They also avoid training to the south of California State Highway 108 until the snowpack is at least 0.61 m (2 ft) high (*Id.*). We continue to work with DOD to develop appropriate conservation measures for Sierra SNRF for the final INRMP.

#### State Regulations

*California Hunting and Trapping Regulations*: The State of California classifies red foxes as a furbearing mammal that is protected from commercial harvest (14 C.C.R. 460), and provides protection to Sierra SNRFs in the form of fines between \$300 and \$2,000, and up to a year in jail for illegal trapping (114 C.C.R. 465.5(h)). Body-gripping traps are also generally prohibited in California, so accidental harvest of Sierra SNRF incidental to legal trapping of other species is unlikely (see Hunting and Trapping, above). Between 2000 and 2011, approximately 150 trapping permits were sold annually in California (Callas 2013, p. 6); thus, the effects of legal trapping to all species combined are probably low. Licensed trappers must pass a trapping competence and proficiency test, and must report their trapping results annually. Scientists who are trapping Sierra SNRFs for research purposes must obtain a Memorandum of Understanding

from the State (California Fish and Game Code, Sections 1002 and 1003, and Section 650). Additionally, strict trapping and handling protocols must be adhered to by researchers to ensure the safety of study animals (*Id.*). However, California law does allow killing of foxes other than SNRF for depredation of crops or property (Stermer *et al.* 2017, p. 3).

*California Endangered Species Act (CESA)*: CESA (CA Fish and Game Code (CFGF) 2050 *et seq.*) prohibits possession, purchase, or “take” of threatened or endangered species without an incidental take permit, issued by CDFW. SNRF were designated as a threatened species under CESA in 1980 (CDFW 2014, p. 12).

## **7.0 Summary of Current and Future Viability**

The current condition of environmental characteristics important to Sierra SNRF viability is generally good, although in some cases somewhat worse than during historical times. The current condition of demographic characteristics important to Sierra SNRF viability, however, is generally poor, except that reproductive impacts of inbreeding depression appear to have been alleviated by interbreeding with immigrant nonnative males.

Risks to the future viability of the Sierra SNRF appear generally high given the small size and distribution of the current population and likely environmental and demographic stressors. None of the characteristics affecting viability appear likely to follow an increased viability scenario. Likely losses in subalpine habitat and snow depth will tend to cause increased competition with coyotes, and a general loss of habitat. Rodent population sizes will likely remain similar or increase, but access to them will be limited by competition. Leporid and whitebark pine populations are likely to decrease or become less dependable. And while the recent increase in pup production is encouraging, despite the fact that the pups are hybrids, the size and genetic integrity of the population both remain susceptible to a return of inbreeding depression if it fails to increase sufficiently, and to genetic swamping if additional non-natives continue to enter the area and breed. These issues and the limitations to growth imposed by environmental characteristics are likely to keep the Sierra SNRF population from expanding, and thus leave it susceptible to stochastic or catastrophic changes.

Characteristics Affecting Viability		Current Stressors	Current Condition	Likely Future Stressors	Future Condition	Viability Component
Environmental	Subalpine habitat (Low productivity; Cold)	Changing climate conditions	Worse than historical.	Changing climate conditions	Decreased Viability scenario	Resiliency
	Deep winter snow.	Drought (Affected by changing climate conditions)	Generally good. Subject to droughts.	Changing climate conditions Drought (affected by climate)	Partway between Status Quo and Decreased Viability scenarios	
	Rodents	Coyote competition & exclusion	Generally good.	Increased coyote competition.	Status quo scenario	
	Leporids.	Low snowpack. (Affected by climate)	Good in Sonora Pass area. Unknown elsewhere	Low snowpack. Declining or variable population.	Decreased Viability scenario	
	Whitebark pine	Rust disease. Mtn pine beetles Fire	Somewhat reduced, but still important food source.	Rust disease. Mtn pine beetles Changing climate	Decreased Viability scenario	
Demographic	High native genomic integrity	Low reproduction among pure natives	Fair: Reproduction is up, but only hybrid pups observed.	Genetic swamping. Return of inbreeding depression.	Decreased Viability scenario	Representation
	≥ roughly 150 native adults per population	Inbreeding depression	Poor: 10 - 50 adults, including many hybrids	Stochastic events	Status Quo scenario	Resiliency
		Hybridization		Environmental stressors Return of inbreeding depression.		
Larger or multiple populations across representative habitat.	Low population size	Poor: 1 known small population in center of range	Stochastic events Environmental stressors Return of inbreeding depression	Status Quo scenario	Redundancy & Representation	

Table 1: Characteristics Affecting Viability; Stressors; and Current and Future Conditions

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